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AUGUST 1959

IN THIS ISSUE . . .

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SAE journal

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One of New Departure's high volume ball bearings. Low torque characteristics provide the high sensitivity demanded by speed control device.

Photo: Courtesy Perfect Circle Corp.

N/D Bearing Solved Response Problem In New Automotive Speed Control Device!

CUSTOMER PROBLEM:

Extensive testing revealed sluggish response of automobile speed control device.

SOLUTION:

N/D Sales Engineer, in cooperation with manufacturer, recommended replacing existing pure thrust bearing and bushings with New Departure double-shielded ball bearings. These light-duty, non-loading groove bearings, with uninterrupted ball raceways, withstand radial and thrust loads in any combination. This change resulted in virtually friction-free operation of the speed control device, correcting the response problem. What's more, these New Departures eliminated a lubrication problem and simplified assembly and maintenance.

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NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Production Holds Key to Reliability

Based on paper by

J. M. WUERTH

North American Aviation, Inc.

THE production man, as well as the engineer, faces a great challenge in trying to meet the reliability requirements of the space age. If he is successful, the payoff will be tremendous. Success, however, will demand all of the technical ingenuity and the psychological motivation which he can muster.

Where practicable, production processes will have to be mechanized. Where this is not practicable, the workmen will have to be motivated to provide the utmost in careful workmanship. Inspection, control, and screening processes will have to be strengthened and measurement standards will have to be further refined.

If, through these techniques, we can assure the consistency of manufacturing processes, then what used to be considered uncontrollable random sources of unreliability can either be eliminated or converted into known sources of unreliability. Once identified, American creative ingenuity can usually find some solution for a problem. We should therefore expect that this will also be true of unreliability whenever its sources can be properly identified.

To Order Paper No. 46S . . .
on which this article is based, see p. 6.

Infra-red Collision Warning for Aircraft?

Based on paper by

L. H. CHASSON

Lockheed Aircraft Corp.

BOTH passive and cooperative infrared aircraft collison warning devices have a good potential usefulness. However, the design of the passive system must be very advanced to make up for lack of control of target radiation characteristics. Background discrimination and sensitivity are major problems with this type of system.

On the other hand, good cooperative systems can be designed, provided the aircraft operator doesn't wince at having to provide as much as a kilowatt of power to a radiant source. There is some promise that these power requirements can be reduced to a value nearer 100 watts by careful and intensive design and development efforts.

The "ideal" solution would probably be an essentially monochromatic source in the visible or near infrared or — even more desirable — a molecular source and receiver operating at a wavelength in the far infrared. This device could combine the advantage of optical techniques for directional accuracy, and the transmission and efficiency advantages of microwave techniques. This type of problem would seem to be an excellent application for an "infrared maser" in the future.

To Order Paper No. 58S . . .
on which this article is based, see p. 6.

Car Market Demands Wider Range of Models

Based on talks by
HERBERT FISHER, Chrysler Corp.
EUGENE BORDINAT, Ford Motor Co.
and **OLIVER K. KELLEY**,
Buick Division, General Motors Corp.

(Presented before SAE Detroit Section)

STYLISTS and engineers are challenged to design cars for different purposes and adapted to individual needs. And the public will continue to expect annual style change — significant change — which must be backed

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up with excellent quality and well thought out and practical engineering innovations.

This increases the engineer-stylist responsibility. The engineer must conceive, design, develop, and test these innovations. And the stylist must work with these designs after they've been developed and also bridge the gap of an engineering development of long-time span items with appealing and exciting styling. Furthermore, he must aid in promoting the kind of advanced engineering required to make certain marketable styling innovations feasible.

When the engineer wants the new styling job almost as much as the stylist does, he can find less expensive and better ways to rearrange the mechanism to suit the styling. When the stylist wants to save the functional values and the company's money almost as much as the engineer does, he will be happy to take a really hard look at possibly beautiful shapes that can be created with less radical mechanical designs.

Whatever diversification the industry will develop in the future will be done without discarding what has been learned. This differentiation in models may mean a lower profit per unit sold, but the gain in total sales should produce greater overall profits.

Hydraulic Pumps Can Handle Cryogenic Fluid

Based on paper by

CONRAD J. HOHMANN

Vickers, Inc.

POSITIVE-displacement hydraulic pumps and motors can be used effectively with cryogenic fluids. And the inherently large heat-sink capacities of liquefied gases, coupled with the proved reliability and high efficiency of standard hydraulic components, has spurred the development of practical cryogenic power systems.

Some of the problems associated with gas-operated motors are the effects of:

1. Compressibility on performance.
2. Low gas viscosity resulting in reduced volumetric efficiency.
3. Freezing at gas outlet, caused by rapid expansion, and resulting in back pressure. (This can be overcome by outlet modification.)
4. Lack of lubricity in gas.

Performance records show accelerating rates of approximately 10,000 rpm in 0.2–0.5 sec and speeds over 21,000. The ultimate goal is to satisfy the anticipated auxiliary power requirements of high-performance aircraft, missiles, and space vehicles.

To Order Paper No. S194 . . .
on which this article is based, see p. 6.

SRI Explores Use of Lead Precipitate with Engines

EFFECT of fuel containing a precipitate consisting of decomposition products of the fuel on small engine induction systems and combustion chamber deposits are given in CRC Report 326, "Phase VIII — Lead Precipitate Test — Stationary Engine Tests Run at Southwest Research Institute."

The fuel blend used was made up of two gasolines that had been stored at Yuma, Ariz., for more than three years. This blend consisted of 67% straight run, 31% thermally cracked, and 1.5% catalytically cracked with approximately 2.2 ml TEL per gallon. The ASTM gum content of this blend was higher than that permitted by MIL-G-3056 and contained an appreciable amount of lead and/or iron precipitate. In addition, the vapor pressure was low as a result of weathering in storage.

Test results show that:

- Lead was deposited on the throttle plates and in the intake manifolds.
- Engine performance data cannot be directly evaluated in terms of lead content because of the high ASTM gum content of the fuel.
- To properly evaluate the effect of lead precipitates, a synthetic precipitate should be prepared for blending into a fuel of low gum content. The results of such a test could be more accurately interpreted if the AMB insoluble portion of induction deposits formed were analyzed for lead content.

To Order CRC 326 . . .
on which this article is based, see p. 6.

Please turn to page 90

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One in a series of technical reports by Bower

BEARING BRIEFINGS

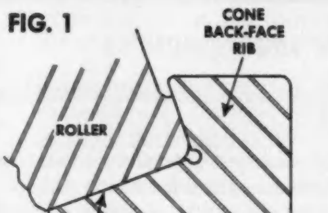
BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

FIG. 1



In the design and manufacture of Bower tapered roller bearings, Bower engineers take great care to generate and hold an exact face angle on the cone back-face rib. In practice, this means that Bower bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.

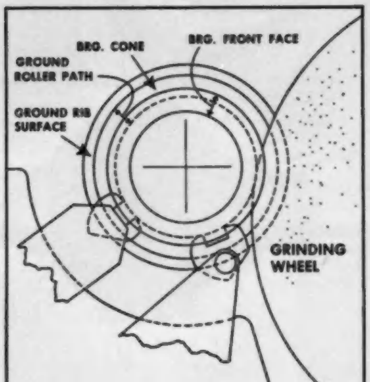
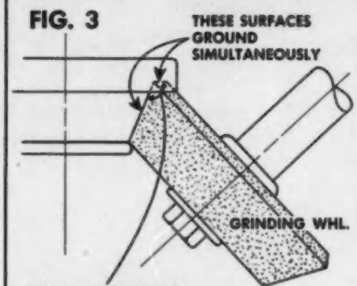


FIG. 2
FRONT VIEW

It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.

FIG. 3



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When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

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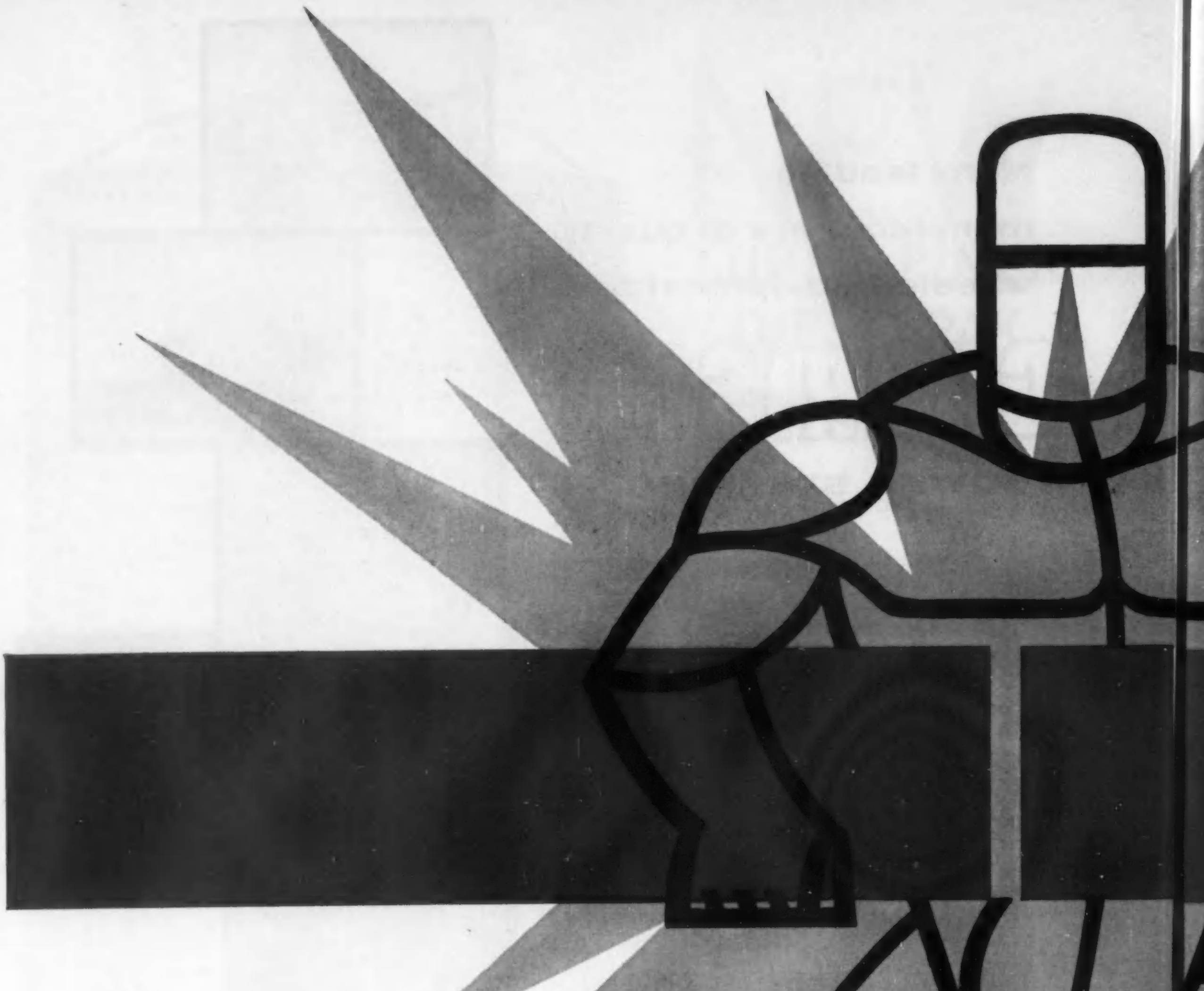

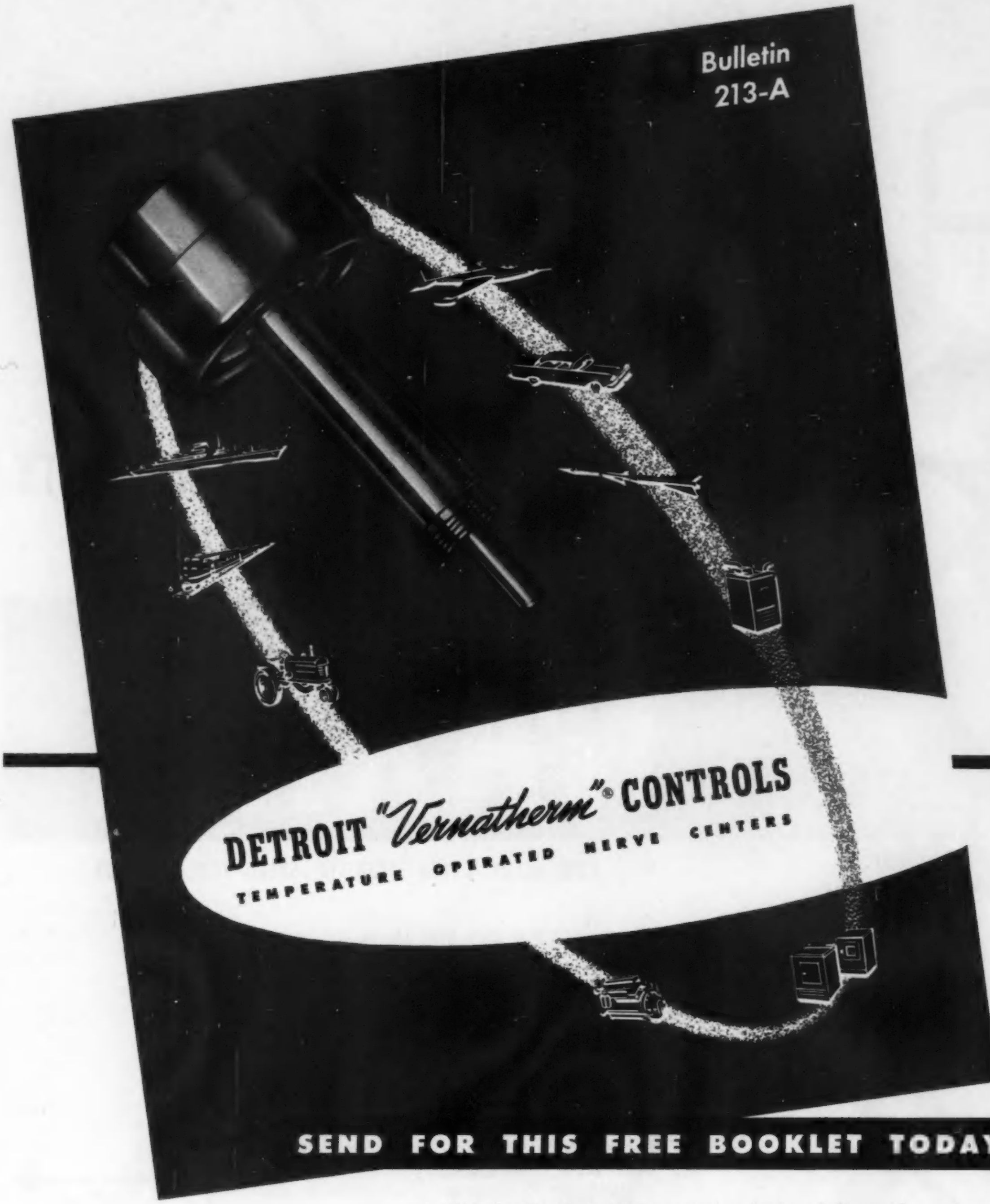

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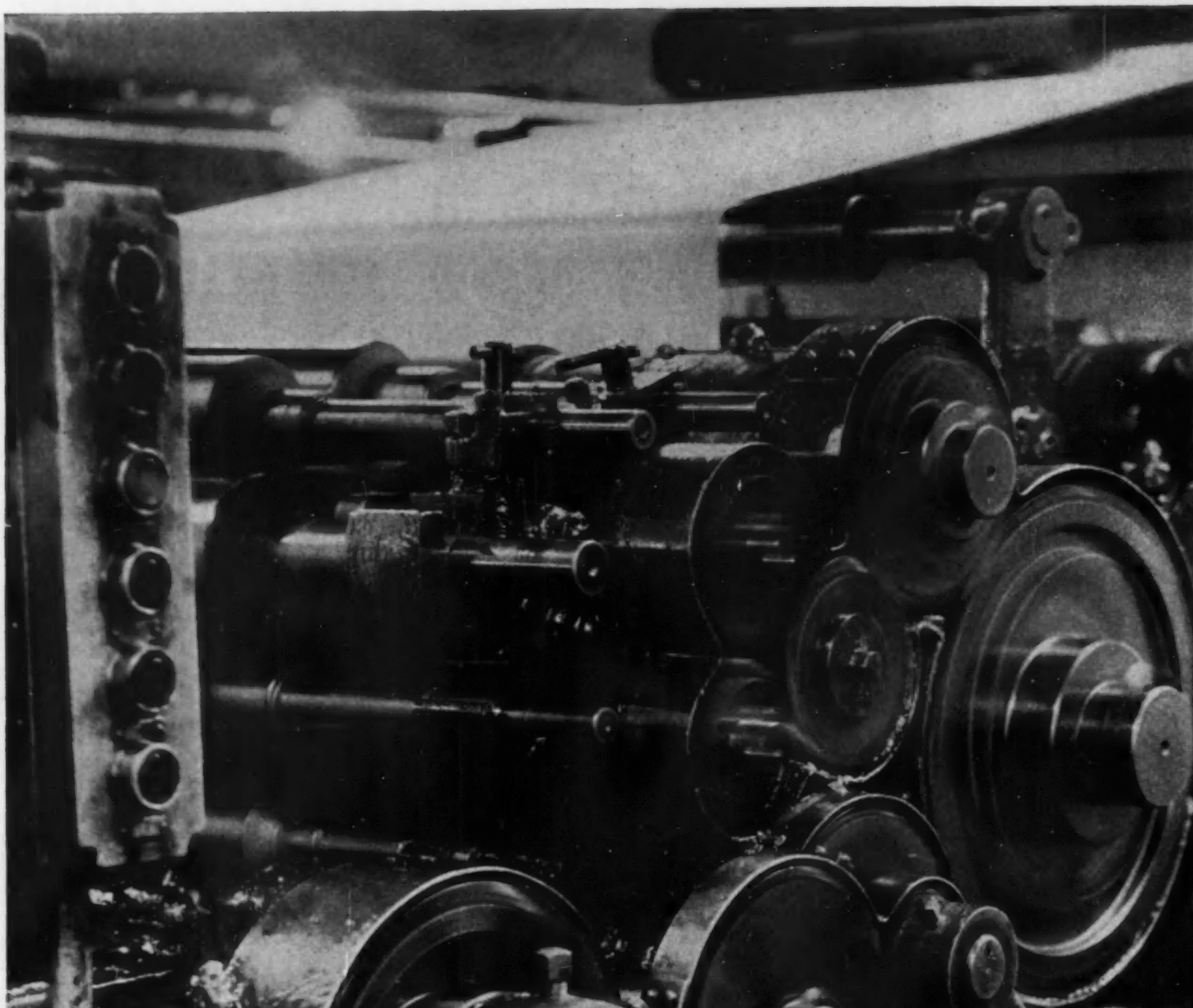

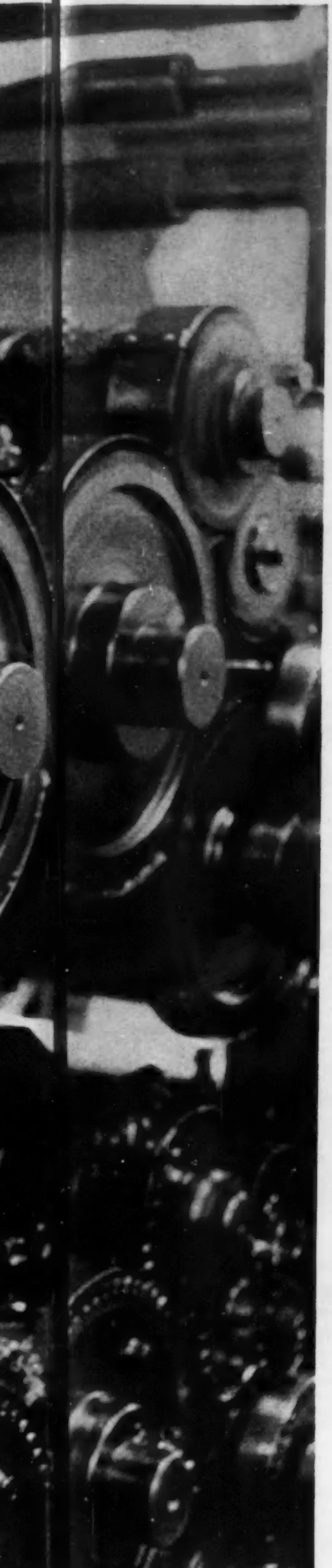

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SAE journal

For Sake of Argument

Managers — Selfmade?

"You don't develop a successful manager; he has to develop himself. The job is to set up a working environment in which the supervisor or potential supervisor *can* develop."

That's a main conclusion reached by one of our largest corporations from years of intensive study and setting up of management development programs.

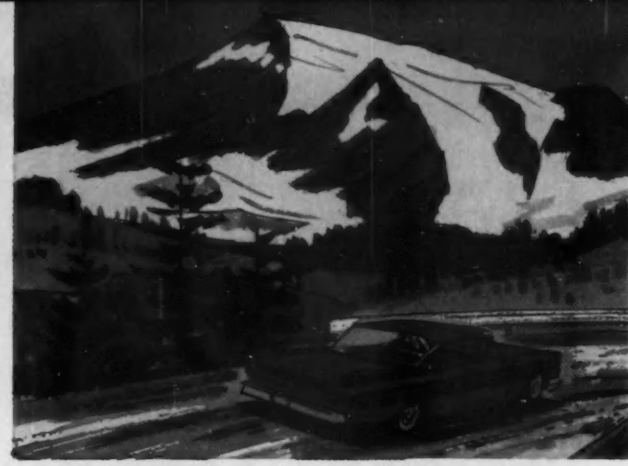
Reversal of classic approaches to supervisor development seems likely to result from acceptance of this concept. It would take the emphasis from training processes as such; shift stress to realigning the work-patterns of existing supervisors. Characteristic of men already rated as good managers, it seems, is that:

- They usually worked for a successful manager or supervisor, and
- They usually have good supervisors working for them.

This "environment" concept seems to say to supervisors at all levels: "Providing future supervisors is just as much your responsibility as is getting the work done each month. . . . So is constant redevelopment of an overall, 2-year-ahead program — for your department and for each of the people in it."

Applying such a concept, a supervisor may find himself training by example instead of by precept. When he does, he will automatically step up his own effectiveness as a manager. At the same time, he'll be creating the best possible environment for other's development.

Norman G. Shidle



FROM NEW YORK: "All four of my brakes are always perfectly adjusted whether I'm on the throughway or driving in bumper-to-bumper traffic in the city."

FROM DENVER: "There's new pleasure in mountain driving now that I know my brakes always have maximum stopping power."

FROM ATLANTA: "Knowing our brakes are never out of adjustment gives me a wonderful safe feeling. I'm at ease even when taking the children to school."

FROM MINNEAPOLIS: "In all kinds of weather, self-adjusting brakes give me stopping power at its best—and save the cost of brake adjustments."

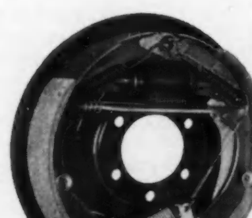
AGAIN . . . BRAKES ARE NEWS IN DEALERS' SHOWROOMS!

Bendix* Self-Adjusting Brakes give dealers a double-barreled sales appeal: safety plus economy. And those in close touch with today's market know that these two appeals—safety and economy—are among the most powerful sales points that can be made to the American buying public.

Car prospects quickly realize that there's real safety in always maintaining the brakes at maximum stopping power. And the obvious savings that they make by eliminating the expense and bother of periodic brake adjustments. What's more, with all brake shoes always correctly adjusted, there's always the right clearance between pedal and floor. And that's a feeling any car buyer appreciates.

Reasons like these make self-adjusting brakes a good "talking piece" for dealers. It won't be long before car buyers everywhere will know about self-adjusting brakes—and want them. But this latest advancement in brakes joins power brakes and power steering as examples of how Bendix pioneers and develops improvements to meet the needs of the automobile industry.

*REG. U. S. PAT. OFF.



When shoe clearance exceeds a predetermined amount, a ratchet sets up the star wheel adjuster one notch—as the brakes are applied when the car is in reverse. This automatically adjusts the shoes to exactly the right fit within the drum and compensates for lining wear.

Bendix PRODUCTS DIVISION South Bend, IND.

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from SAE meetings, members, and committees

COMPUTERS ARE APPROACHING THE "LIGHT BARRIER." The speed of light and electricity, usually thought of as in the realm of infinity for practical purposes, is now not fast enough. . . . The decision element of a modern computer acts in a quarter of a millimicrosecond. Electromagnetic waves take seven times as long to pass over one foot of wire. The march to higher speeds appears to be the key to lower unit cost per calculation. But this march will now require new computer techniques to surmount this barrier . . . . says A. C Monteith of Westinghouse Electric.

STATIC ELECTRICITY IS A PROBLEM WITH FLYING CRANES. A sufficient charge builds up on the helicopter so that when it hovers over its load the man handling the load may experience a shock strong enough to knock him over.

PROPELLANT COSTS in Thor and Jupiter missiles are less than 10% of the cost of the complete missile . . . even for the more promising and more expensive storable propellants. Cost of recharging the missile after a static firing is about 1.6% of the total missile cost.

PAYLOAD/GROSS WEIGHT RATIO of military vehicles needs to be upped from the present 30% to 50 or 70% to provide necessary mobility on battlefields of the future . . . and the U. S. Continental Army Command feels that it can be done.

Development of these higher payload/gross weight ratios on the Army's ground and air vehicles will materially reduce construction and maintenance of fixed communication lines — and will give the flexibility and responsiveness needed to support highly mobile operations.

Too much pride in being right makes us feel all the worse when we turn out to have been wrong.

AT RENAULT, about 25% of the employees own automobiles . . . a much higher-than-average figure for French firms.

THE BEST OF WHEELED VEHICLES in use by the U. S. Army have a 42% chance of achieving 10,000 miles without replacement of a major component . . . . but those which are combat vehicles have only a 3% chance of doing 4,000 miles without such replacement. (Data from survey of 11 domestic major Army posts — plus results of tests of production vehicles at Aberdeen, Yuma, and Fort Churchill.)

AIRLINES PILE UP FLIGHT HOURS FAST. Already even the least-used Pan American jet transport has operated more hours than the most-used KC-135 tanker, which is the first cousin of the 707. In the future we're not going to be able to depend on military statistics for commercial engine reliability data as we have in the past.

Sure, people are funny — but we're all people!

FIFTY AIRLINES are flying turbine aircraft and only one is using JP-4 fuel. All the others use kerosene.

NECESSARY LEAD TIME on new military vehicles in Russia is only about 5 years. It takes about 8 to 10 years to go from concept to items in the hands of troops here in the United States. So, when we try to produce a counter-weapon to a known Soviet development, a 3-4 year period may transpire during which there may be no means at all to combat the enemy's new development. Example: Today we have no defense against Russia's ICBM.

A NEW ELECTRONIC BRAIN called Opcon (for "optimizing control") can discover for itself the difference between a right and a wrong decision . . . and make impartial judgment based on its own experience. Its built-in mathematical logic detects unforeseen changes in a situation and responds sensibly to them — according to Westinghouse Electricity's A. C. Monteith.

BRAZIL IS PUSHING DEVELOPMENT OF AUTOMOTIVE MANUFACTURE within its boundaries, and is requiring steadily increasing Brazilian content in vehicles assembled within the country. Among vehicle companies operating within Brazil or with published commitments are: Ford, Willys-Overland, Simca, Alfa Romeo, DKW-Vemag, Borgward, Toyota, Mercedes-Benz, Volkswagen, and International Harvester. There also are other manufacturers of farm tractors and heavy equipment. Most plants are in the Sao Paulo area. Total investments, coupled with those of parts makers, are expected to reach more than $1 billion by 1960. Vehicles produced, mostly jeeps and trucks, totaled 33,000 in 1957 and 61,000 in 1958. Goal for 1959 is 110,000 and 217,000 for 1960.

Fig. 1 — Front view of Volga resembles 1951 Ford passenger cars. Bumpers are in three pieces, joined underneath overriders. Car features one-shot lubrication, short wave radio, and reclining seats. It is easy to enter and relax in deep, comfortable seats.

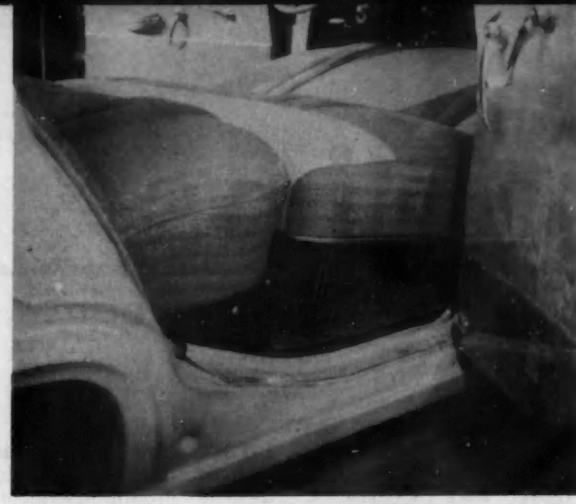

Fig. 2 — With front seats all the way forward, legs are pulled from seat back and lowered to make a long, comfortable bed. Rear seat cushion should be reversed to complete operation and provide level surface.

Russian Cars

The VOLGA—

Russia's medium-price car

RUSSIA'S medium-price car is the Volga, shown in Fig. 1. A 1958 sedan available for inspection had one-shot lubrication, short wave radio, and reclining seats (Fig. 2). Known as the model M21-A Volga, its appearance is somewhat like a Henry J, a 1951 Ford, and a great deal of the 1952 Mercury mixed together. Doors are big (Fig. 3) and it was easy to enter and relax in deep, comfortable seats. The 80-hp engine idles quieter than anything in its price class, but doesn't provide enough gallop to keep up with American traffic. I found the hydraulic clutch smooth and gear shifting easy. But steering was miserable and the rough ride could be compared to a small pickup truck.

Inspecting the car

Several hours of careful inspection produced a number of notations . . . reproduced here verbatim. In back: trunk lid has a rotary, keyed, lock . . . dull black paint, and cardboard inside trunk . . . separate light under lid . . . vertical mounted spare . . . backup light . . . rubber gaskets between bumper and sheetmetal . . . good chrome.

From back seat: wonderfully comfortable and three-people wide . . . covered with blanket-like material over cotton and coil springs . . . dome light controlled by switches on left front and right rear doors . . . 4¼ turns to raise a window . . . tempered glass in doors . . . rear vents are not movable . . . doors lock with GM-type pushbuttons . . . waffle paper glued to roof under headlining . . . nubby brown tweed carpet.

In front seat (Fig. 4): seat is of good height, but uncomfortable decorative pad runs up the middle of my back . . . gear shift is easy but second and high slow to mesh as though syncro rings have trouble . . . full horn ring, . . . suspended pedals (Fig. 5) . . . excellent double-swivel bracket for each sun visor . . . dash is odd combination of excellent and awful workmanship with untrimmed castings, mold marks, chipped and spotted paint . . . good instrument dials (Fig. 6) . . . nice plastic wheel . . . stamped metal glove box lid has inspection sticker with name of man approving car . . . radio antenna above windshield in center, like '36-'38 Fords . . . front doors have two separate rubber seal strips, plus windlace (Fig. 7).

Under the hood (Figs. 8–11): instructions to clean oil filter (in English), "Move handle back and forth 20 times daily when engine is hot, remove and wash every 20,000 km" . . . plenty of room to service . . . underhood light . . . hydraulic reservoirs easy to reach . . . carburetor hidden under hat-type cleaner . . . thermostatic exhaust gas valve . . . aluminum engine looks like copy of Chevrolet four . . . battery grounds to fender sheet metal.

General comments: paint well applied but not as shiny as our production . . . panel fit is smooth but door gaps indicate poor die matching . . . chrome window trim is well fitted, but hand work shows . . . extensive (and not very good) lead work showing at top and bottom of windshield posts . . . layer of

Fig. 3 — Doors of Volga open wide, permitting easy entry to comfortable interior. Like the smaller Moskvich, this sedan has rough road ground clearance and enough space around tires to make wheel changing easy.

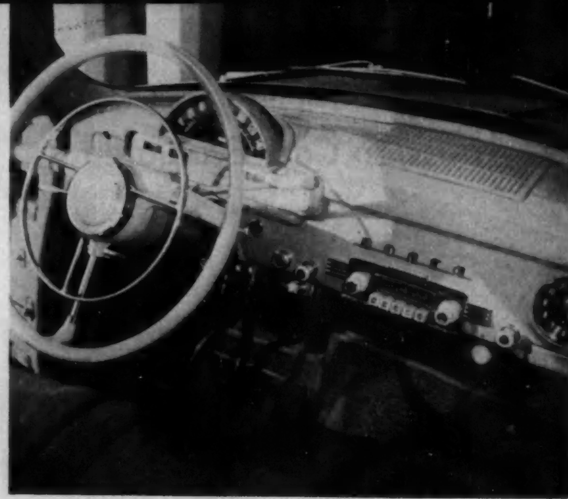

Fig. 4 — Dash is not modern, compared to our styling. All controls, except the heater, are plainly marked. Speedometer — similar to that of 1955 Fords — has a plastic top to outline numerals and indicator. Full-circle horn ring and ivory plastic wheel are comparable to our best. Radio offers both long and medium wave band reception, though distortion was evident at high volume.

Evaluated

for SAE Overseas Information Committee

By William Carroll

. . . who has had an opportunity to ride and drive the Russian 1958 model Volga and Moskvich cars — as well as to examine them in detail. (Only minor differences in specifications appear in the 1959–60 models of these same cars displayed at the recent Soviet Exhibition of Science, Technology and Culture held at the Coliseum in New York City.)

An associate member of SAE, Carroll is head of Coda Publications and a technical journalist. The opinions are those of the author.

mastic is blade-applied under fenders . . . front and rear bumpers pieced together under the overriders . . . exceptionally quiet electric wiper motors . . . red light on dash when park brake on . . . green light if engine overheats.

Engine: simple overhead-valve four made of aluminum with wet iron liners . . . oil pump buried inside pan with common shaft driving distributor off camshaft . . . forced crankcase ventilation into air cleaner . . . single downdraft carburetor has adjustable main jet needle . . . distributor points adjusted by cammed screw.

Body and chassis: unit body with bolt-on frame horns from cowl forward to support engine and front suspension . . . coil springs in front, leaf springs in rear . . . dual piston shock absorbers are used all around . . . to be refilled every 6000 km.

The Volga is rated as a five-passenger car and ac-

A description of the Moskvich — Russia's compact car — starts on page 32.

Russian Cars Evaluated

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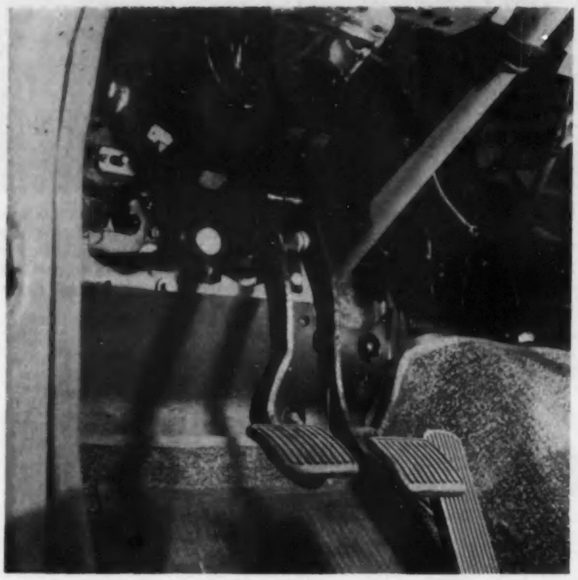

Fig. 5 — Suspended pedals provide plenty of room for big feet. The shiny button is stepped on once a day to complete chassis lubrication through one-shot system. Chrome handle of hand brake was a knee bumper if hand brake was on while entering or leaving the car. Rug in front passenger area had two rubber inserts, one for driver, the other for passenger.

cording to the maker operates on 80-octane fuel. Compression ratio is 7.5/1. The 149.15 cu in. engine has a bore and stroke of 3.68 by 3.68 in. Horsepower is rated at 80 (at 4000 rpm), up from the 70 listed in 1956 Maximum torque is 130.7 ft-lb. Replaceable wet liners are fitted through the top of the aluminum block. An aluminum-alloy cylinder head has valves installed vertically in-line. Inlet valve diameter is 44 mm, exhaust valve diameter is 36 mm. Pistons are tinned aluminum alloy with two compression rings and one oil ring. Compression rings are chrome plated, oil rings tin plated. There's a five main bearing crankshaft (listed as magnesium cast iron) with balance weights, statically and dynamically balanced at the factory.

All bearing surfaces are hardened and inserts are thin wall bimetal. Crankshaft and camshaft bearings, connecting-rod bearings, rocker-arm bearings, and push-rod upper end pieces are pressure lubricated. Two oil filters are installed in the Volga engine; one, the laminated coarse filter passing all oil forced by the pump into the pressure line, plus a fine filter with replaceable element passing only part of the oil. There are two check valves in the lubricating system, one a reduction valve of piston type installed in the right front part of the engine and the second a bypass valve in the coarse filter body.

The air cleaner (Fig. 9) is an inertia oil-bath (with screen) unit with suction noise muffler. The single throat, down-draft carburetor has an acceleration pump and built-in economizer valve. A diaphragm-type fuel pump has a manual priming lever and inverted sediment bowl incorporating a screen filter. The pressurized cooling system has a centrifugal water pump with self-adjusting sealing gland. A

Fig. 6 — From driver's point of view there is a well-spaced array of instruments. Speedometer is in kilometers (though car used English decals under hood).

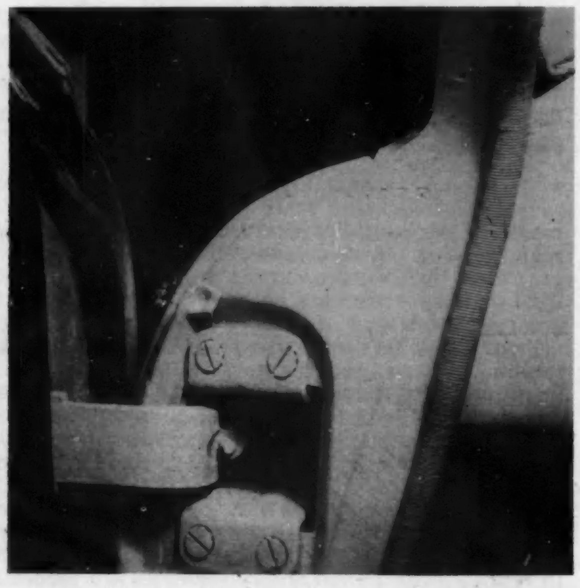

Fig. 7 — Volga door hinges are adjustable and are equipped with grease fittings to provide semipermanent lubrication. Note use of two seal strips, plus windlace, to eliminate chance of cold air entering car.

Specifications for Two 1958 Russian Cars

	Volga-M21-A	Moskvich-407
Curb Weight, lb	3212	2156
Length, in.	193	162
Width, in.	72.0	61.6
Height, in.	64.8	62.4
Wheelbase, in.	108.0	94.8
Tread (max), in.	56.8	48.8
Road Clearance, in.	7.6	8.0
Turning Circle, ft	41.3	39.0
Maximum Speed, mph	85	65
Engine	4-stroke, 4-cyl gasoline	4-stroke, 4-cyl gasoline
Bore & Stroke, in.	3.68 × 3.68	3.00 × 2.96
Displacement, cu in.	149.15	83.0
Valves	Overhead, push-rod	Overhead, push-rod
Compression Ratio	7.5/1	7/1
Horsepower at Rpm	80 at 4000	45 at 4500
Torque, ft-lb at rpm	130.7 (rpm not available)	63.5 at 2600
Firing Order	1-2-4-3	1-3-4-2
Axle Ratio	4.555/1	5.14/1 (36 & 7)
Tires	6.70 × 15 (tubeless)	5.60 × 15
Battery, v and amp-hr	12 and 54	12 and 42
Fuel Tank Capacity, gal	16.0	9.3
Radiator Capacity, qt	12.5	8.0
Crankcase Capacity, qt	6.0	4.3

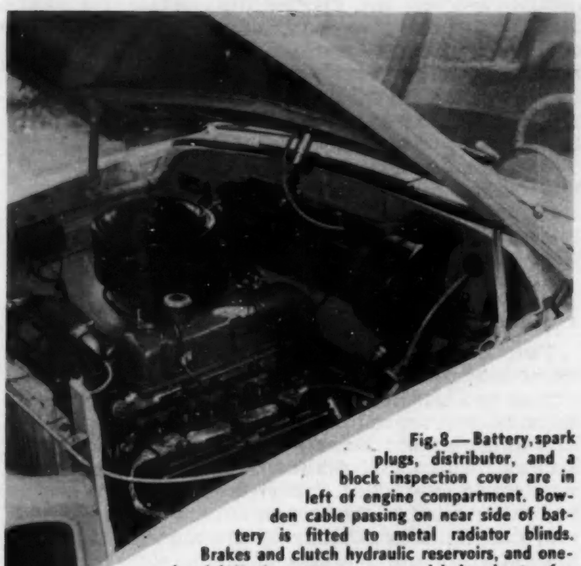

Fig. 8—Battery, spark plugs, distributor, and a block inspection cover are in left of engine compartment. Bowden cable passing on near side of battery is fitted to metal radiator blinds. Brakes and clutch hydraulic reservoirs, and one-shot lubrication sump are on cowl below heater fan motor.

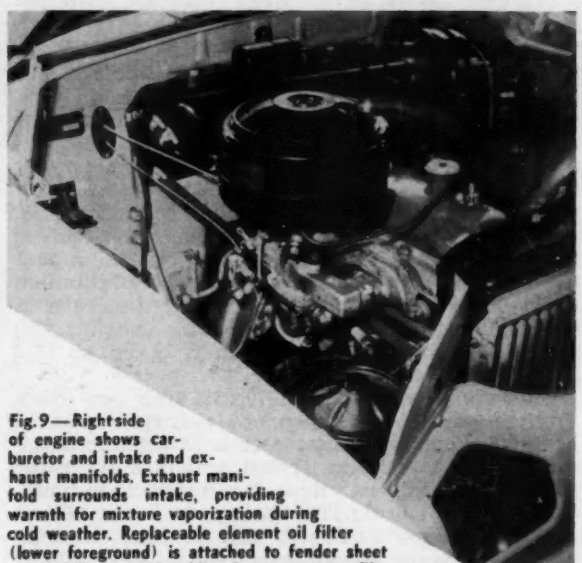

Fig. 9—Right side of engine shows carburetor and intake and exhaust manifolds. Exhaust manifold surrounds intake, providing warmth for mixture vaporization during cold weather. Replaceable element oil filter (lower foreground) is attached to fender sheet metal. Wire-wound rubber hose connects filter to engine and pump. Oil is added through cap on valve rocker box cover. Clip for an accessory oil can is located just below the maker's plate.

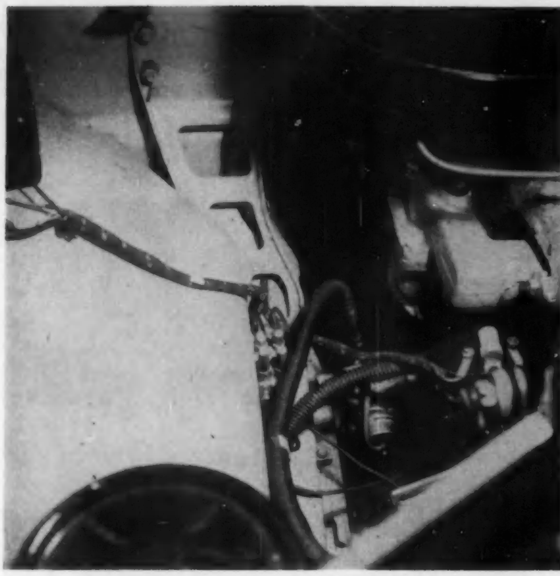

Fig. 10 — Wire wound rubber hose connects the fine (replaceable element) oil filter with the pump and coarse filter. Coarse filter uses movable plates, which are to be shifted 20 times daily to maintain clean oil flow. Bypass in coarse filter protects engine if daily maintenance is not carried out. Portion of stub frame supporting engine and front suspension is bolted to cowl. Air cleaner is an inertia oil-bath (with screen) unit with suction noise muffler.

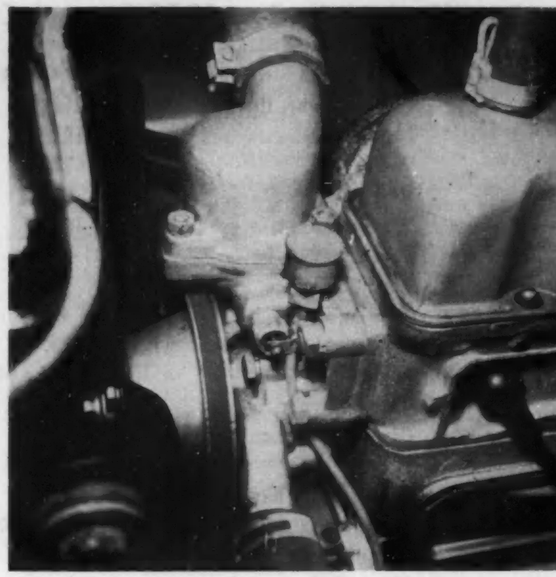

Fig. 11 — Last stand of the grease cup! Water pump bearings are lubricated with frequent twists of an old-fashioned grease cup — on a car that features one-shot chassis lubrication. Cooling system thermostat is above water pump, and controls a bypass to recirculate water within block for rapid warmup. Sending unit for temperature gage is between thermostat and block. Hose to top of rocker box cover leads to air cleaner to provide forced crankcase ventilation.

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thermostat is installed in the cylinder head. It begins to open at 70 C and is fully open at 83 C.

Power transmission was originally announced (in 1956) as through an automatic transmission. The 1958 car tested has a single-plate dry clutch with hydraulic release mechanism. The transmission is a 3-speed unit (plus reverse) with syncromesh on second and third. The shift lever is on the steering column. Gear ratios are: first, 3.115; second, 1.772; third is 1/1; while reverse is 3.738/1. Two open-type propeller shafts are used with three needle bearing universal joints. A center bearing is rubber mounted. Final drive is by hypoid gears with pinion offset below the axle shafts. Differential ratio is 4.555/1. Ball bearings are used for the semi-floating axle shafts and torque reaction is taken by leaf springs.

Tubeless, low-pressure 6.70×15 tires are used. Front suspension is independent lever type on coiled cylindrical springs mounted on a detachable crossmember. A torsion bar stabilizer is in front of the suspension members. Rear suspension is by longitudinal semi-elliptic leaf springs in boots. Front and rear shock absorbers are refillable double-acting, hydraulic piston, lever type. Steering is by worm and roller with a mean ratio of 18.2. Hydraulic brakes are the four wheel, shoe type, with a hand brake band on a drive shaft drum behind the transmission.

The battery is 12 v 54 amp-hr, with positive ground. The 220-w, shunt-wound generator feeds through a three unit current and voltage regulator. The ignition coil includes a resistor, which is switched off when the engine is cranking. A centrifugal and vacuum spark advance control, plus octane selector, are on the distributor (Fig. 12). Spark plugs use 14-mm threads. Headlamps, with country and traffic beams, are semisealed optical units with 50 by 21-cp bulbs inside the lens assembly. The system is protected by button-type bimetal circuit breakers in the lighting circuit and three melting fuses for other equipment. The instrument cluster (Fig. 6) includes an ammeter, gasoline gage, oil-pressure gage, water temperature gage, and speedometer with odometer. The clock is wound electrically and the radio reaches long and medium wave bands with manual and button tuning (Fig. 4).

Evaluating the car

Two automotive engineers inspected the Volga. Their tape recorded comments follow:

"Car exhibits handicraft of low production American models . . . coach joints in doors have been solder and finish ground . . . cap-type roof is welded to the roof rail with a full drain trough running over the windshield (Fig. 13) . . . vinyl-type sealer appears to have been used in the trough . . . rubber windshield and backlight weatherstrips are showing signs of deterioration due to attack of Los Angeles ozone . . . door weatherstrips, of sponge with thin skin, are beginning to crack from ozone. . . .

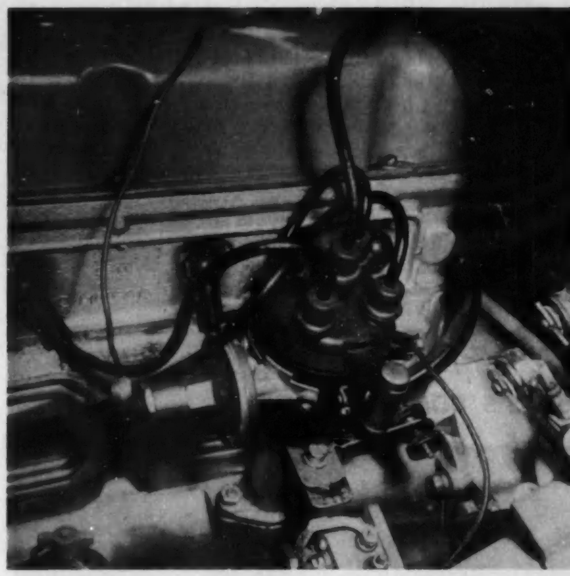

Fig. 12 — Ignition system is distinguished by extremely short leads from distributor cap to spark plugs. Distributor has both centrifugal and vacuum control. Vernier octane control is on right, with adjustment pointer below case.

Fig. 13 — Roof cap features full gutter over windshield with plenty of lead and grinding to provide well finished coachwork. On Volga tested, roof was "working" at top of left A post and signs of corrosion were beginning to appear. No chrome or decorative trim covers rubber around windshield.

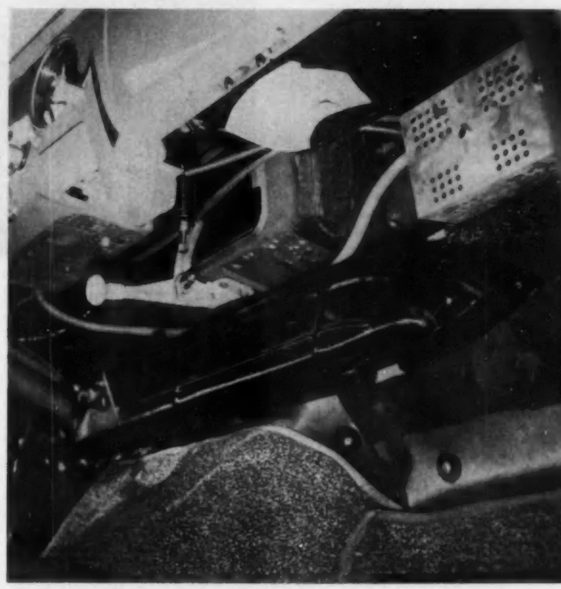

Fig. 14 — Air distribution chamber for heater is of metal, rather than pressed fiber used on most American cars. Radio is installed in three sections: tuning unit in panel, power supply on cowl, and speaker under dash. Limp paper under glove box shows body was approved by chief inspector of Gorki plant.

Hood hinges are counterbalanced coil spring hinges with two gear sectors on the upper and intermediate link . . . the coil spring is lighter than that used on most American hoods . . . hood latch is controlled from the passenger compartment . . . grill is chrome plated carbon steel . . . joints in front sheet metal have been soldered . . . corners of hood have been patched and soldered . . . finish on car is somewhat better than on Moskvich, still not up to American standards . . . paint appears to have been applied after some assembly work was started. . . .

"Some bolts show paint others not being painted . . . body cloth used is quite soft, appears to have no latex backing . . . vinyl used on upper parts of the backs has the tacky finish which has been avoided in American-built cars for almost 10 years . . . heater duct inside car is steel stamping rather than molded paper felt used in most American cars (Fig. 14) . . . trunk lock is similar to the door lock . . . the rotary striker is more complicated and expensive than our current locks . . . gas filler door has a positive over-center spring, which feels more like a bear trap than a gas filler door. . . .

"Moldings are really simple, straight sections . . . hardly any stampings or complicated die working involved in the automation . . . general appearance of instrument panel is of our designs of five or ten years ago . . . we found no complicated draws in the sheet metal or complicated die castings that give the appearance of depth, which the Volga panel lacks . . . speedometer has transparent hood like 1955 Ford . . . head lining is retained by tacks with "hide-em" strip covering the tack heads . . . better attention could be paid to corrosion or rust resistance . . . roof panel at left hand A post top is "working" and rusting in crack . . . area where floor door panel is attached to the upper door frame is cracking and beginning to corrode . . . there's an absence of plated fasteners . . . no soundproofing inside doors . . . lock is separate from the handle of the door, being mounted about one-third down on the door panel . . . use of an aluminum engine with wet liner is believed to be predicated on lack of machine tool facilities in

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the back country where overhauling engines would be easy with new liners . . . otherwise it would be impossible to rebore a block . . . in the Volga there are few Phillip head screws, except around trim at base of seat and on windshield reveal . . . use of welt material between outside rear panel fenders on both sides."

Latest reports indicate the Volga is due to be imported into the U. S. in an improved model with slightly more powerful engine, plus better trim and ride. The cars examined were originally intended for use in Europe. However it is noteworthy that each car (Volga and Moskvich) was equipped with an English operator's manual, while the Volga made extensive use of English decals in the engine compartment to advise a new owner of his responsibility toward the car.

The MOSKVICH—Russia's compact car

Fig. 15 — Inspection of doors, windshield frame, and top show Moskvich resembles Hillman. Front sheet metal looks somewhat like 1950 Ford, reduced in size. There is plenty of ground clearance and room to change tires. What appear to be vent panes in rear doors are solid sections, fitted to square off windows so they can be lowered.

THE small, low-priced, Moskvich-407 is a four-door sedan, with styling that bears a strong resemblance to the 1950 Hillman (Fig. 15). Entry is not difficult, though interiors are a bit small for drivers over 6-ft tall. The front seat adjustment consists of two large wing nuts holding clamps on each seat support (Fig. 16). It takes four minutes to adjust the wing nuts and move the seat to a new position. Interior trim quality of the Moskvich is better than average, considering its low price of $900, based on wholesale cost in Czechoslovakia. Instruments (Fig. 17) are large and of good quality. The radio and heater worked well. Clutch, brake, and accelerator pedals pivot below the floor; and all three are stiff and difficult to control.

The engine starts quickly by turning the ignition key. An adjustment rod on the left side closes metal radiator shutters (Fig. 18), bringing operating temperature to a peak rapidly. Forward vision is fair, but the car is so underpowered (45 hp at 4500 rpm) that driving is difficult in city traffic. High gear was useless below 20 mph, while driveshaft and wheel vibration eliminated conversation above 45. The ride is firm but not uncomfortable, considering the size of the car.

Cornering is comparable to any stiffly sprung small car. It steered more lightly than most imports inspected recently. Maximum speed on a 32% grade was 13 mph in low. Brakes provide fast stops without fade or wander. The body was noisy and the ventilating system barely adequate.

After driving the car for several hours, a number of notes were made.

Trunk (Fig. 19): interior painted after assembly, rubber floor mat . . . spare upright on right side . . . metal X brace between rear seat and trunk . . . deadener not used inside . . . screws and nuts not plated . . . license light illuminates trunk when lid open . . . Hillman hood brace holds trunk lid up . . . latch opened by cable from lever at base of rear seat.

Outside: cover over gas tank filler (like '58 Ford) is locked by trunk lid which must be opened before refueling . . . bumper chrome is thick . . . rubber gasket under chrome tail light . . . aluminum body trim strips . . . door panels are one-piece stampings.

Three turns to raise a window . . . no insulation inside doors . . . left-hand front door has lock . . . fat velour windlace covering ragged edge of wheelhouse flanges . . . vinyl (stiff and thin) and fabric door panels . . . dual windshield wipers.

Back seat: comfortable and chair height . . . covered with fabric and vinyl . . . flannel type headlining . . . screw setting quality on par with Detroit . . . coat hooks on center pillars . . . dome light switch on light cover . . . floor pan dropped about three inches below sill.

Rear seat cushion: uses foam over very fine coils (for light passengers) in a tangled mass, plus layer

of "screen door springs" stretched over a floor pan indentation to catch heavy passengers compressing the fine coils.

Front seat: sit high . . . head clearance okay . . . clutch and throttle very stiff . . . cowl vent . . . radio distorts at high volume . . . selective and powerful . . . horn ring under wheel rim . . . two sun visors.

Under hood (Figs 20–22): no soundproofing . . . front fenders easy to take off . . . simple carburetor . . . aluminum intake manifold is water jacketed . . . battery and brake reservoir easy to service . . . radiator mounted in rubber and can be moved an inch in any direction . . . car was painted after assembly . . . oil bath air cleaner . . . rubber hose connects engine to oil filter mounted next to radiator . . . rubber overflow hose on radiator.

Body and chassis: unit-body construction . . . engine hung on stub frame welded to body under cowl . . . independent front wheel suspension on coils . . . leaf springs in rear . . . tubular shocks . . . tiny tailpipe (Fig. 23) must restrict performance . . . 8 in. of ground clearance . . . tire tread is 7/16th in. deep.

Engine of the Moskvich is 4-cyl, 4-stroke gasoline with 3.00 by 2.96 in. bore and stroke. Displacement is 83 cu in., though in 1956 it was listed as 65.5 cu in. when the engine used a 2.61 bore. Compression ratio is 7.0/1. Maximum torque is 63.5 ft-lb at 2600 rpm. Fuel consumption listed by the factory is 35-40 mpg (Imperial?). Firing order is 1-3-4-2. The cylinder block is one piece, of cast iron. Anticorrosive iron liners are press fitted. The cylinder-head is gray iron or aluminum. Pistons are aluminum alloy with a T-slot oval skirt. There are three compression rings and one oil ring on each piston. The upper ring is chrome plate, second and third compression rings tin plated. The piston pin is floating with circlip retainers.

Connecting rods are forged steel, double T section, with thin-wall bimetal replaceable inserts and bronze threaded bushings at the upper end. The crankshaft is believed to be forged, rather than "stamped steel" as listed by the factory. It's a three-main-bearing unit with counterweights, oil grooves, and dirt traps (closed by threaded plugs in the crankpins). The shaft is statically and dynamically balanced with bearing surfaces hardened by high-frequency current. Main bearings are bimetal, replaceable inserts. The three bearing camshaft is forged steel with bearing surfaces and cams hardened by high-frequency current. Camshaft bearings are bimetal threaded bushings and the drive uses a Texolite driven gear. Inlet valve diameter is 32.2 mm, exhaust valves are 28.8 mm. Inlet valves are of chrome steel and exhaust valves of silchrom (sic) steel. Valve springs are variable pitch, tappets are adjustable cast iron and exhaust valve seat inserts are heat resistant iron. The cooling system is pressurized and equipped with a thermostat. Metal radiator blinds are controlled from inside the car. A centrifugal-type water pump is V-belt driven, the impeller shaft packed with an adjustable oil gland. A four-blade stamped fan is on the shaft.

Engine lubrication has oil forced to the crankshaft, camshaft, main and connecting-rod bearings, and camshaft gears. Working surfaces of all other parts are splash lubricated. The oil pump, driven from the camshaft, is inside the crankcase. Unique in the Moskvich are two oil filters. The first, a coarse circular plate filter passes all oil supplied by the pump. A fine filter with replaceable element is mounted on the oil branch pipe. Crankcase ventilation is forced, by suction through a connection to the air cleaner.

The 9.3-gal fuel tank is in the rear under the trunk floor. Filler neck is at the center (somewhat like recent Fords) equipped with an airtight plug and two tubular air vents. The plug is covered with the hinged bracket of the license plate, which is locked in place by the trunk lid.

The fuel pump is the diaphragm type with built-in sediment bowl in the head and outside lever for

Fig. 16 — Front seats have five-position adjustment, by means of wing nuts holding seat supports on each side. No method of vertical adjustment is provided. Dark sections on instrument panel are die cast plastic, in colors contrasting with surrounding paint.

Fig. 17 — Instruments are good, with legible figures and stable needles. Dark instrument cluster insert is high-quality die cast plastic.

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manual fuel pumping. The single throat down draft carburetor has a balanced diaphragm accelerator pump and economizer with mechanical control from the throttle linkage. The air cleaner is an oil bath inertia contact type with filter element connected to an intake silencer. The aluminum water jacketed intake manifold is on the left, the branch-type cast-iron exhaust manifold on the right (Fig. 24). The engine is mounted on two rubber pads in front at the middle upper part of the crankcase and on a third pad under the transmission extension.

A single plate dry clutch has the torque vibration damper in the hub of the driven plate, which has an outer diameter of 184 mm. The transmission has three forward speeds and one reverse. All gears have helical teeth, the main shaft with spiral splines. Synchronization is on second and third gears only. The shift lever is on the steering column. Gear ratios are: first, 3.53; second, 1.74; third, direct; and reverse, 4.61. The open tubular drive shaft has two universal joints with needle bearings. A sliding connection is in the transmission extension on the main shaft. Differential gears are 5.14/1, using 36 and 7 teeth with two pinions and semifloating axle shafts of the flange type. Transmission of power from rear axle to body is through the springs. The rear-axle housing is a stamped beam of two parts, welded together.

Rear wheel suspension is by means of longitudinal semi-elliptic springs of progressive action with shackles on the rear eyes. There are nine spring plates per assembly and pivot connections with the body are through changeable rubber bushings. Hydraulic double-acting tubular shocks are used front and rear. There's independent front wheel suspension with traverse levers (no kingpin) assembled on a forged cross-piece fastened to the stub frame through rubber pads. A torsion stabilizer bar, across the front, is fastened on the bottom of the suspension arms.

Because the Moskvich features unit body construction, the engine is mounted on a stub frame consisting of two box-section girders connected by a cross-member in front. The frame is welded to the body with no provision for quick replacement. A forged drawbar eye is set on the cross-member ahead of the engine.

Stamped steel disc wheels, with removable caps, have a 4JK15 rim section and five wheel studs. Brake drums are composite steel disc and cast-iron rim, fastened to hub flanges of front wheels and axle shaft flanges in the rear. Tires are low pressure, 5.60 by 15. Foot braking is through two-shoe hydraulics, on all four wheels. Front brakes are equipped with two wheel cylinders and floating-type brake shoes. The hand brake, through cable and extension handle, acts only on rear brakes through an equalizer. All brake cylinders, including master cylinder, are 22 mm in diameter.

There is a 12-v 42-amp-hr positive ground battery. The ignition coil resistor is automatically cut off when the engine is cranking. The coil is on the

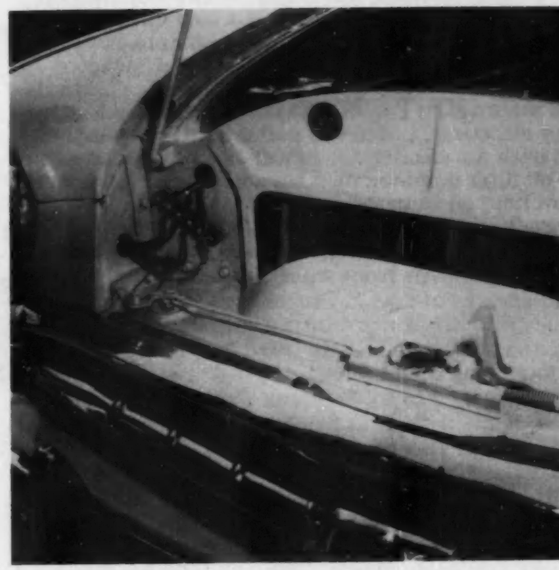

Fig. 18 — Complicated hood release mechanism has Bowden cable from right side of front seat to point at right of radiator. Here it attaches to an angle lever, which in turn pulls rod, releasing latch. Wiring is connected by terminals and screws, with no quick fitting used. Metal radiator blinds can be controlled from driver's seat.

Fig. 19 — X brace between trunk and seat back, plus deep back panel, provide exceptional rigidity to rear of Moskvich body. Spare tire is dropped into well, while raised trunk floor allows room for gasoline tank underneath. Latch holding lid is identical to fixture used by Hillman to hold their hood.

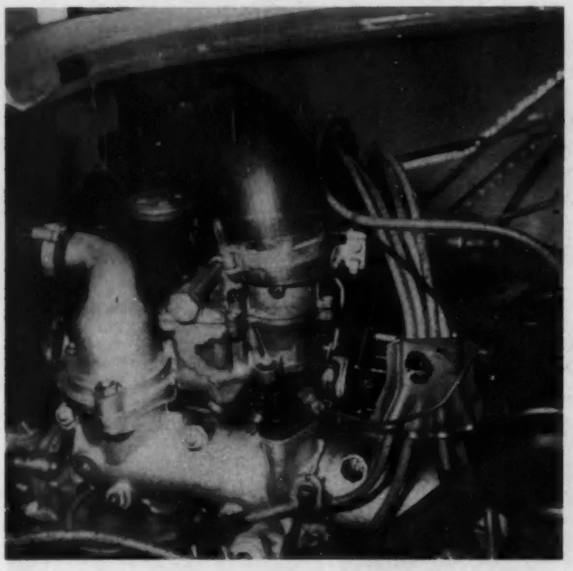

Fig. 20 — Simple, single throat downdraft carburetor is mounted directly to water cooled heated intake manifold. Air is brought to carburetor from air cleaner by large rubber tube. Vacuum for distributor control is taken from carburetor at throttle plate closure point. High tension wires are braided and lacquered linen, over rubber — a form of construction not used here for many years. Spark plugs are almost buried under manifold.

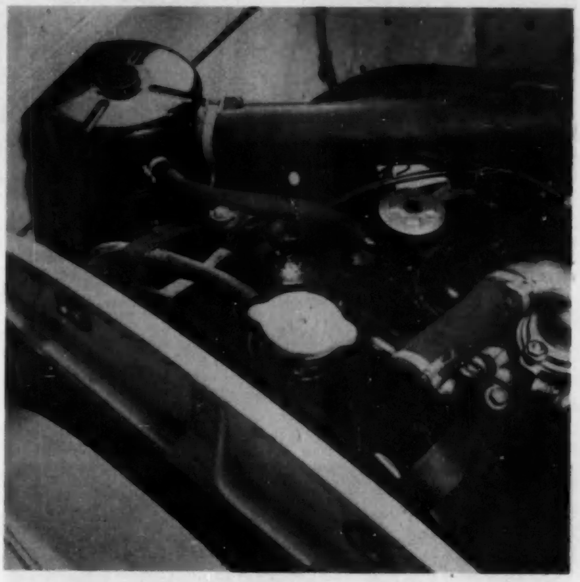

Fig. 21 — Two metal strap brackets over radiator top are fitted with rubber bushings (similar to Lord mounts), allowing radiator to move an inch in any direction. Coolant overflow is carried away by rubber tube. Air cleaner and silencer is connected by large rubber tube to carburetor, and by small rubber hose to rocker box cover to promote crankcase ventilation.

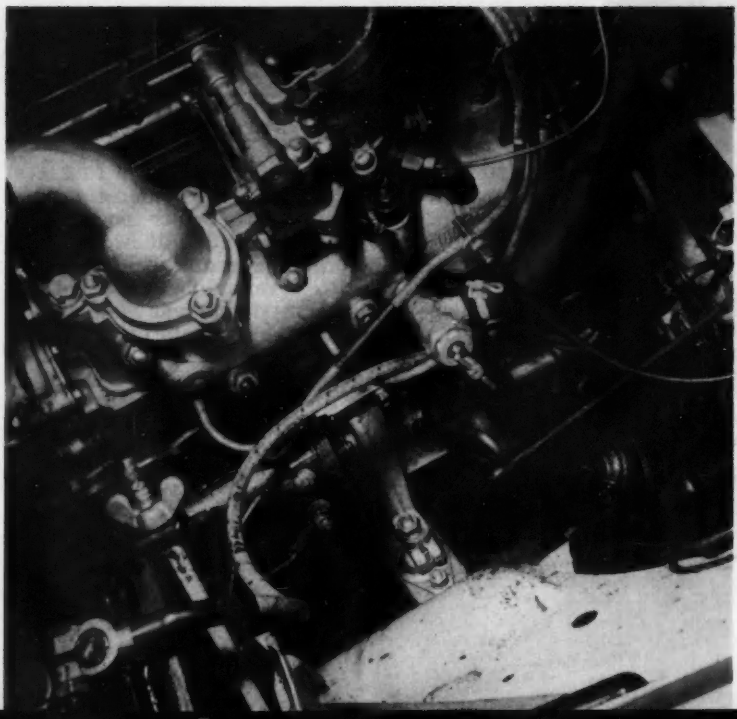

Fig. 22 — Battery is held in place by angle bracket and two wing nuts. Intake manifold is on left, above starter and generator. Thermostat in system is in elbow fitting between manifold and radiator. Heater inlet hose take-off is on intake manifold, and equipped with shutoff valve for warm weather driving. Bowden cables control throttle plate settings.

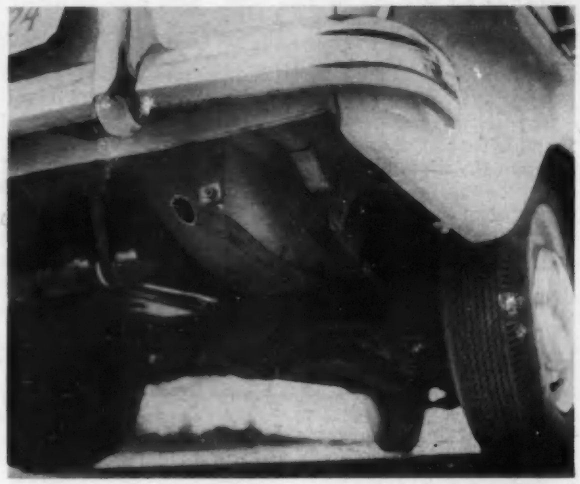

Fig. 23 — Tiny tailpipe appears to offer serious restriction. Exhaust pipe, from engine to muffler, has at least four times tailpipe capacity. Spring shackles are fitted to thick metal brackets welded to floor section of unit body. Gasoline tank and running gear are black enameled.

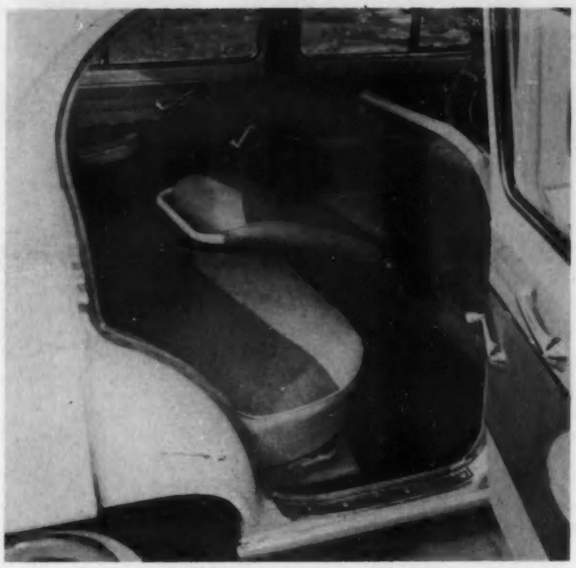

Fig. 25 — Front seats have a common two-passenger cushion with individual, pivoted back rests. Seat backs tilt forward for convenient entrance to back seats, or fold backward so that, with cushion moved far forward, sleeping accommodations are available.

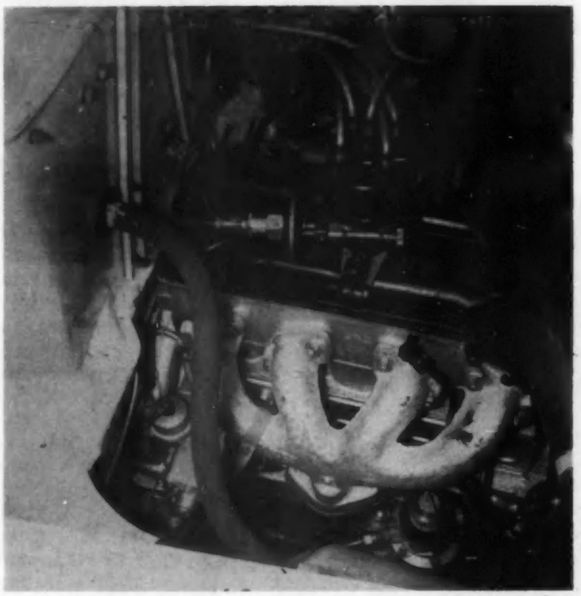

Fig. 24 — Right side of engine has vacuum and centrifugal controlled distributor mounted high on head. There is a control on vacuum mechanism to adjust rate of advance. Grease cup lubricates distributor shaft. Branch-type cast-iron exhaust manifold is in open, though too near fuel pump to eliminate vapor lock on American deserts. To left of exhaust pipe is coarse oil filter. It is to be cleaned by twisting handle 20 times, once a day while engine is warm. Oil pressure gage sender is on coarse filter body, which also incorporates a bypass valve to prevent engine damage, should filter clog.

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front body panel under the hood. The distributor uses centrifugal and vacumatic advance regulation, plus an octane selector. The 200-w generator is shunt wound. Spark plugs are one-piece construction.

Instruments in the Moskvich included a fuel level gage, coolant temperature gage, speedometer, and wiper switch. The all-metal four-door sedan uses a single stamping for the door and window aperture. Body equipment includes heater and windshield defroster, glove box with cover at right side of the instrument panel, two sun visors, rear view mirror, ash tray, clothes hooks, rubber mats on the floors and in the luggage compartment.

Doors are locked from inside by turning the handles. The left front door can only be locked from outside with a key. All glass is tempered, with windshield and backlight curved slightly. Front seats have a common two-passenger cushion with individual pivoted back rests. Seat backs tilt forward for convenient entrance to back seats, or fold backward for sleeping accommodations (Fig. 25). Seat movement allows adjustment according to length of

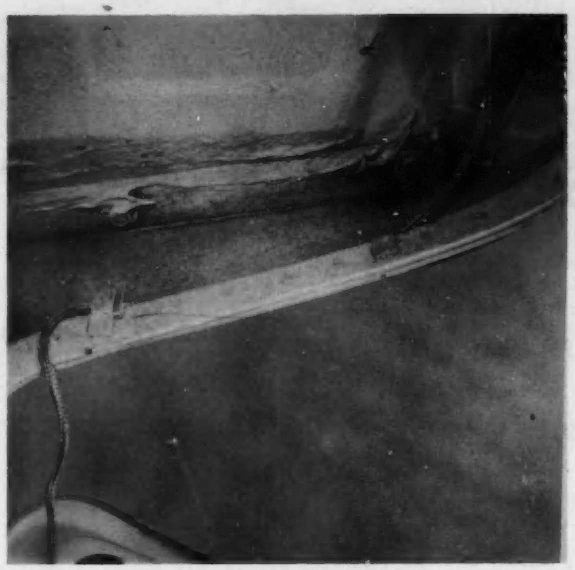


Fig. 26 — Rear fender panels are attached to body with capscrews from inside trunk. Blade applied mastic is used for dust and water sealing. Moskvich has aircraft-quality wire loom for license plate light.

Fig. 27 — Rear fenders can easily be removed for repair or replacement. No sound control material was used under panel. Windlace is an extruded U section covered with velour, which is snapped over a flange, resulting when inner and outer panels are spotwelded together. Door latches are not the "safety" design now used in our cars.

driver's legs. Front and rear fenders bolt on, while rear fenders have a mastic lining to reduce noise (Figs. 26 and 27). The alligator hood is opened from inside the car. In the open position the hood is held by a manually set support rod. Bumpers are stamped steel, chrome plated, and fitted with vertical overriders. Enamel is used as the body finish.

Some further comments

Tape recorded comments by two qualified automotive engineers are as follows: "Welding in hood area appears to be a mixture of full spots and arc or gas . . . gas weld on inner retainers . . . no counterbalance springs or torsion bars on the hood . . . quality of the paint considerably below American standards . . . some edges show primer or bare metal . . . car uses expensively made hood lock (Fig. 18) . . . remotely controlled from right side of the front compartment . . . conventional safety latch . . . grille appears to be chrome-plated carbon steel . . . Russian headlight with bulb inside the sealed lens unit . . . many time-saving features of attachment used in American cars not found . . . electric wiring has conventional terminals, sleeving, and is screwed to terminal blocks . . . rubber parts withstood ravages of Los Angeles smog quite well . . . door weather strip rubbers are sponge with thin skin covering, staining pair of door reveals . . . outer panel stampings of the doors are not hemmed over inner, they are nested together with flange on both inner and outer panels left at 90 deg to the surface . . .

"They use molded plastic to quite an extent . . . avoided color combination problems we get into with plastic panels by making plastic a contrasting color instead of trying to match adjacent paint . . . windcord appears to be extruded rubber section designed to wrap around spot welded flange of all openings, rather clever design . . . antenna installed inside front compartment, leaving a raw edge on the right side . . . quarter panel appears to be a fly panel, as well as some of the area around the trunk . . . trunk lid has no torsion bar or springing . . . door lock and striker pretty much same design Ford and GM are now using . . .

"Body cloth used on door panels rather thin printed vinyl to match body cloth . . . general appearance of interior is not as well conceived as some American products . . . it looks something like a truck rather than a passenger car . . . tendency to use small, simple stampings without much complicated die work . . . There are many sharp flanges and abrupt surface changes that would cause excessive die wear . . . they probably use dies longer than we do on some models . . . there doesn't seem to be much atention to water sealing in the cowl area . . . few nuts and bolts are sealed . . . welding of roof panel to roof rail has been quite well done and would pass our standards . . . they haven't done too well on dies, when they come to a sharp corner, generally a hole has been left which has not been sealed smoothly . . . in attaching door hinges to the pillar they provide access holes through sheet metal, into the hinge attachment points."

Fuel Cells—New Power

The process is much like that of the flashlight

materials and method's make the fuel cell much more

DIRECT CONVERSION of the chemical energy of gases into electricity — long a dream of scientists and for years a laboratory curiosity — has been accomplished with the development of fuel cells capable of economically producing thousands of watts of power.

Present designs call for the grouping of a number of specially catalyzed, hollow porous carbon electrodes in a sealed cell containing a solution of potassium hydroxide as the electrolyte. Hydrogen and oxygen enter the cell through the hollow electrodes, and diffuse through the porous carbon to the surface, where they come in contact with the electrolyte. At the hydrogen electrode, the electrochemical reaction with the potassium hydroxide produces water and releases an electron that enters the electrical circuit. The electron flows through the external circuit, and returns to the cell at the oxygen electrode, where in the electrochemical reaction of the oxygen and the electrolyte, the electron is accepted. Ionic conductivity through the electrolyte completes the electrical circuit.

In theory, the fuel cell converts 100% of the available chemical energy to electrical energy at zero load — that is 100% of the heat energy available from burning hydrogen and oxygen. (By contrast, the efficiency in the Carnot cycle is 25 to 30%.) In practice, however, the efficiency of the fuel cell is only about 80% maximum due to electrochemical considerations. The efficiency of commercial units will probably be in the 65–70% range.

A hydrogen-oxygen cell gives about 0.8 v per cell. The cells can, of course be arranged in series to give any desired voltage. Output is about 1 kw per cu ft in current working units. Power output depends partly on operating temperature of the cell. An increase from room temperature to 120–140 F gives noticeably better power density.

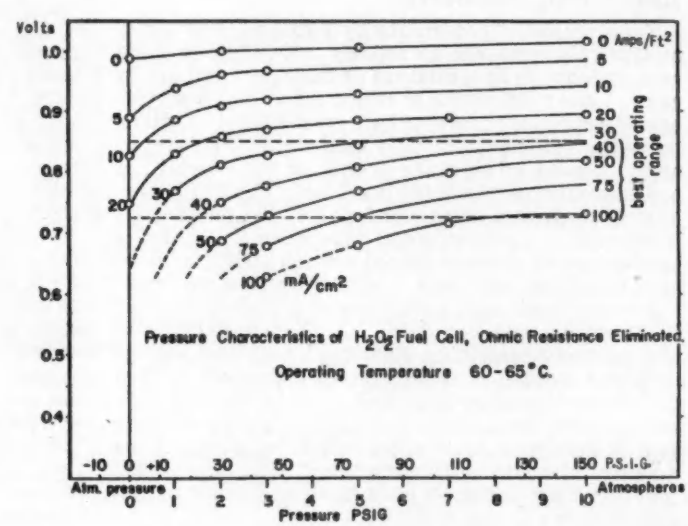


Fig. 1 — Operating voltage of a hydrogen-oxygen fuel cell as a function of gas pressure, for various values of electrode current density.

Source

battery but new

powerful and efficient.

Gas flow is a function of power output. It takes about 40 cu ft of hydrogen gas to develop 1 kw-hr. Fuel cells are, at present, being run experimentally at 1–3 atmospheres pressure. The higher the pressure, the more favorable the power density.

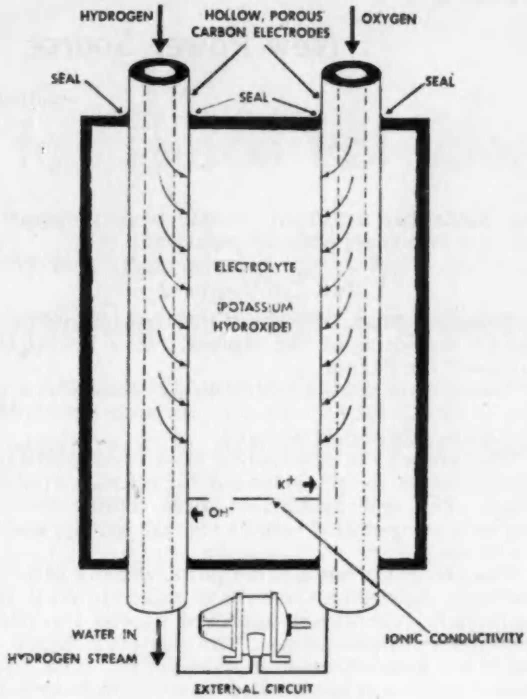
Fig. 1 shows the operating voltage of the cell as a function of gas pressure, for various values of electrode current density. The same data are redrawn in Fig. 2 to show the direct influence of changes in current density upon operating voltage.

Operation of the fuel cell requires a source of hydrogen. In portable batteries where fuel weight is important and hydrogen generating equipment must be light and simple to operate, metal hydrides are an excellent fuel. Generators for use with calcium hydride or lithium hydride require only the addition of water to supply a steady source of hydrogen. In larger installations hydrogen can be obtained from catalytic cracking of various compounds such as ammonia, hydrocarbons, or other organic materials. The selection of a source of hydrogen for each particular application depends upon the relative importance of such factors as weight, portability, initial cost, and fuel cost.

The cheapest and most readily available source of oxygen is air. Operation on air is often preferable in low density or atmospheric pressure installations. Under these conditions, the use of air rather than pure oxygen lowers the voltage about 0.04 v per cell. Maximum power density is realized through the use of pure oxygen, particularly in pressurized systems. Pure oxygen is relatively simple to transport and store as a liquid, or can be prepared by decomposition of peroxides.

Unlike conventional batteries, fuel cells remain essentially unchanged during their operating life, and produce electrical energy from chemical fuels supplied as needed. The fuel cell is merely a sealed jar into which are fed hydrogen and oxygen through the special hollow electrodes. The electrochemical reaction of the gases at these electrodes produces an electric current, with only water as a by-product. With the water disposed of by evaporation, the life of the fuel cell is theoretically unlimited. Labora-

Simplified Fuel Cell



The above drawing illustrates the basic operation of the fuel cell. Hydrogen and oxygen gases enter the cell through specially-treated, hollow porous carbon electrodes, and diffuse to the surface, where they come in contact with the electrolyte, a solution of potassium hydroxide. At the hydrogen electrode, the electrochemical reaction releases an electron, which flows through the external circuit and is accepted at the oxygen electrode. This flow of electrons is the current that powers electrical equipment. Ionic conductivity through the electrolyte completes the circuit, and the water formed in the reaction passes from the cell in the hydrogen stream.

THE INFORMATION contained in this article was discussed at a meeting of the SAE Aircraft Powerplant Activity Committee. The discussion was led by Dr. C. E. Larson, National Carbon Co. and Dr. A. M. Moos, Universal Winding Co., Inc.

Fuel Cells—

New Power Source

. . . continued

tory model fuel cells have, to date, been in operation for over two years without maintenance.

Fuel Cell Variations

Patterson-Moos Division of Universal Winding Co. has been working on two types of fuel cells, the Hydrox and the Carbox.

The Hydrox cell is a hydrogen-oxygen cell operating at 453 F and 600–800 psi. Its nickel electrodes feature a differential porosity.

The company is now tooling for a 1½-kw unit operating at 28 v. It's intended for aircraft applications. The unit consists of three components: 1) the generator or fuel cell, 2) the gas supply, and 3) a control.

The generator has a rated power density of 10 kw per cu ft, figured on the basis of gases stored in ICC containers (containers approved by the Interstate Commerce Commission). The system's figure of merit is commonly given in w-hr per lb. With liquified oxygen and pressurized gaseous hydrogen (at – 193 F in a Dewar flask) the figure of merit is 300 w-hr per lb. The efficiency is 65–70%, based on the free energy intrinsic to the system.

Because of the handling problems inherent in pressurized gases and the high operating temperature of the generator, the Hydrox system is expected to be restricted to military applications.

The Carbox system operates at 500–600 C. It delivers 60 amp per sq ft. The efficiency based on free energy is 64%. The efficiency based on thermal energy depends on the fuel.

The Carbox system has a power density of 500 w per cu ft. It has operated for more than 1000 hours on a variety of fuels and under varying load conditions. The Carbox system is expected to have broader commercial appeal than the Hydrox system.

Applications

Fuel cells are being considered for space-vehicle propulsion. This is because of the lightness of their fuels and because of their efficiency. The fuel cell rates better on a kw-hr basis for long-term continuous service than any power source except solar and nuclear power. It might be possible to use nuclear energy to supply the hydrogen and oxygen for a fuel cell. Strontium 90, which is a nuclear by-product, breaks up water into hydrogen and oxygen — which could serve as fuel. This process would be continuously regenerating, since the by-product of the fuel cell is water. Unfortunately, with nuclear conversion the yield of hydrogen and oxygen is low (about 5%). The rest of the energy goes into heat. The yield of gases might be raised somewhat, but it isn't likely to be raised beyond 10%.

First significant application of the new fuel cells is in providing silent electrical power for the U. S. Army Signal Corp's new Silent Sentry. The world's smallest known radar set, the lightweight, portable unit provides mobile Army forces with local combat surveillance of enemy movements despite smoke, darkness, or fog. A battery of fuel cells provides power to operate the radar set.

Fuel cells aren't being considered very seriously at present for general use for vehicle propulsion because of their relatively low power density. Of course, there is no bar to improving power density. With real ingenuity energy output per unit volume might be raised to values which would make the fuel cell attractive for propulsion, especially where extended attention-free service is necessary.

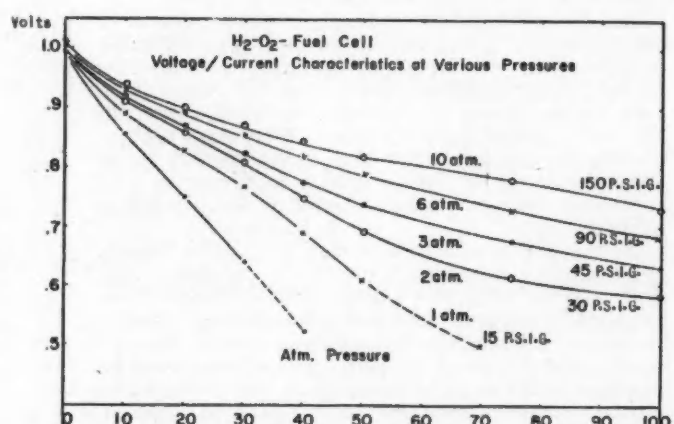


Fig. 2 — Influence of changes in current density upon the operating voltage of the hydrogen-oxygen fuel cell.

MOLYBDENUM—

—vanguard material for space vehicles

Today it is brittle at room temperature and has many other shortcomings . . . but its promise makes knowledge to be gained from handling it well worth the risks involved.

Based on paper by

Alan V. Levy and Saul E. Bramer

Marquardt Aircraft Co.

MOLYBDENUM and its solid-solution alloys form the vanguard of the refractory metals that will be used in advanced space vehicles. Its ability to perform at elevated temperature service conditions is already established. Now, experimental evidence of its ductile behavior below 0 F indicates that knowledge to be gained in handling today's brittle-at-room temperature molybdenum will be well worth the risks taken.

Molybdenum has had by far the most extensive application in components, although columbium-base alloys are currently showing promise, too. Molybdenum's great virtue as a high-strength structural material at temperatures above 2000 F is apparent from Fig. 1. There is shown the ultimate strength of as-rolled and stress-relieved, commercially pure 0.5% Ti alloy and 0.5% Ti, 0.07% Zr experimental alloy. The per cent increase in tensile strength for the first three alloys to come out of the laboratoroy is extremely promising.

The high modulus of elasticity of molybdenum is also an attractive property, especially where thin sheet metal structure is desired. So is the excellent creep strength of molybdenum alloys. Table 1 shows some of the short time tensile and creep properties of ½% Ti-molybdenum alloy at temperatures from 2400 to 3000 F. For the low-load, high-temperature environment for limited time periods of atmosphere re-entry or high-altitude hy-

Table 1 — Elevated Temperature Mechanical Properties of 0.5% Ti-Molybdenum

Tensile Properties

Test Temperature	Material Thickness, in.	Soak Time, min.	0.2% Yield Strength, psi	Ultimate Tensile Strength, psi	Elongation, %
2400	0.060	0.5	33.500	39.900	5
2600	0.060	1.5	11.900	18.900	12
2600	0.040	1.0	11.400	16.200	10
2800	0.060	1.5	8.400	15.000	22
2800	0.040	2.0	8.700	12.400	10
3000	0.060	0.5	5.700	9.800	30
3000	0.040	1.0	6.700	10.800	20

Strain Rate: 0.001 in./in./sec to yield.
0.01 in./in./sec to fracture.

Creep and Stress Rupture Properties

Test Temperature F	Stress, psi	To obtain Creep Strain of Time, sec					Time to Rupture, sec	Elongation, %
		1.0%	2.0%	3.0%	4.0%	5.0%		
2400	28,000	180	280	296	—	—	300	7
2600	10,000	37	82	122	266	—	272	8
2600	7,000	860	1800	2900	3810	4900	5400 [a]	5.8 [a]
2800	7,500	57	180	336	505	663	1405	14
2800	6,000	1474	2520	—	—	—	3300 [a]	2.5 [a]
3000	4,500	56	113	170	214	246	290	12
3000	4,000	252	472	700	835	1060	1380	13
3000	3,500	238	720	[b]	[b]	[b]	2883	16

[a] Test stopped at this time and elongation.
[b] Extensiometer slipped off specimen.

personic flight, molybdenum is shown to be good. For longer life applications, present molybdenum alloys are well suited for service at temperatures in the 2000–2500 F range. Fig. 2 shows the creep and stress rupture properties of the ½% Ti-molybdenum alloy at 2400 F.

The physical properties of molybdenum also are well suited for high-temperature service. The combination of relatively high thermal conductivity, low thermal expansion coefficient, good specific heat, and a reasonably high emissivity of a coated surface makes this material well suited for exterior surface application on severely aerodynamically heated components. Table 2 lists some of the more important physical properties.

Molybdenum's good side, in fact, is clear. The uniformity and level of the following properties are considered acceptable and on a par with the general metal producing industry:

1. Ambient tensile strength and elongation.
2. Chemistry (except for somewhat questionable level of interstitials such as oxygen and nitrogen).
3. Surface condition and flatness (after surface grinding 0.002 in.–0.005 in.)
4. Formability and weldability.
5. Machining is not too difficult. (Usually molybdenum cuts like stainless steel.)

The acceptable status of the first four of these properties has been reached only in the past year. Previously, almost any level of a given property could be expected from heat to heat and even from sheet to sheet within a heat. This improvement alone is gratifying.

Molybdenum's inherent good qualities for space vehicle structures, in other words, are so clear as to make the overcoming of its shortcomings a worthwhile challenge to the metals industry. Overcoming these limitations will lead to provision of the most efficient materials system possible for about 2000 F structural applications.

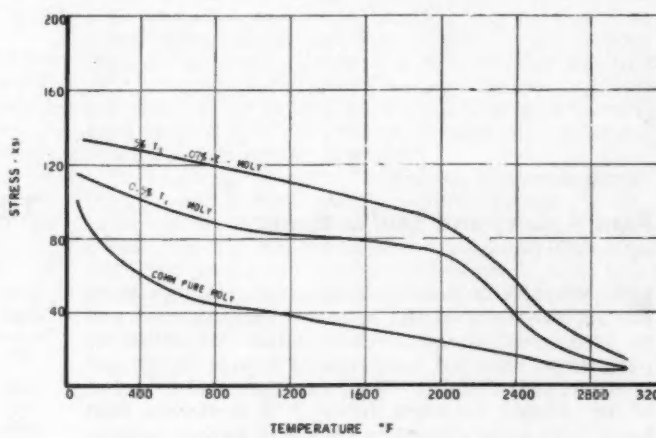


Fig. 1 — Ultimate tensile strength versus temperature for various refractory metals.

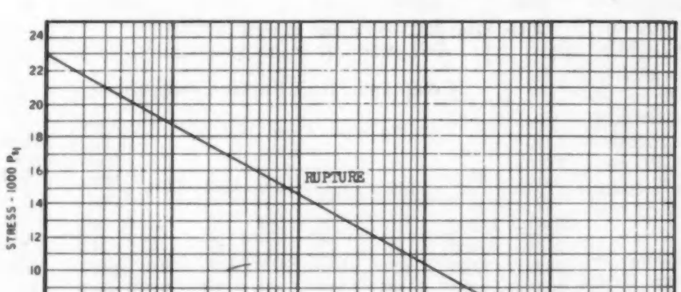


Fig. 2 — Creep and stress rupture curves for 0.5% Ti-molybdenum alloy at 2400 F in the recrystallized condition.

The shortcomings — the "unacceptable-level properties" — that one must live with for the present include:

- Brittle behavior at room temperature.
- Inability to resist oxidation at elevated temperatures; presence of laminations in the material.
- Tendency of molybdenum sheets to propagate cracks at very fast rates in a direction that is 45 deg from its rolling direction.
- Necessity to introduce cold work into the sheet during its last rolling reduction and after the final annealing treatment.
- Because of lack of room-temperature ductility, all handling, forming, and joining must be done at elevated temperatures.

Brittle-Ductile Transition Temperature

The most critical shortcoming of today's molybdenum alloys is brittle behavior at the lower temperatures. While certain laboratory and a few production heats have exhibited tensile and bend transition temperatures below 0 F, most heats have a bend transition temperature at or above room temperature.

Fig. 3 shows the variation in bend transition temperature from heat to heat over a relatively large number of heats. One of the interesting aspects of the bend transition property, as shown by the dotted lines on the curve, is the significant improvement that can be made by surface grinding off contaminated material. But only when the as-rolled surface is quite contaminated, resulting in a bend transition temperature above about 200 F, is removing this surface beneficial.

The problem of improving the brittle-ductile transition temperature property of molybdenum alloys is a complex one that must be aproached by an across-the-board development program aimed at every phase of production from reducing the ore to rolling the sheet bar into sheet.

Laminations

Molybdenum alloy sheet metal has a tendency to form laminations. Available rolling mill equipment for producing steel sheet is limited to metal working temperatures of about 2300 F. Since molybdenum alloys do not recrystallize until temperatures of 2300–2400 F are reached, all reduction of molybdenum has to be done cold or below the recrystallization temperature. Because it is being rolled at less than 50% of its melting temperature, large differential shear stresses exist between the layers of sheet passing through the rolls, inducing shear separation and areas of high residual shear stress primarily along the flat grain boundaries that exist in the plane of the sheet. Also, the inability of laps and seams (present from the initial operations) to weld together as rolling progresses contributes to laminations. Any load applied to the finished sheet that has a force component that adds to these highly stressed areas or acts upon actual separation can open up laminations in the material.

The problem of laminations is primarily tied to the conversion process into sheet form. Rolling at true hot rolling temperatures should markedly improve this problem area. Making lower per cent re-

Climax Molybdenum's Norman L. Deuble comments that:

- **It is possible today to break down molybdenum ingots by extruding them at less than one-half their melting point.**
  - Plans exist for modification of a drop forge press to permit refractory materials to be heated to temperatures in excess of 3500 F for extruding.
- **A standard test needs to be developed — either a bend or impact test — which will evaluate sheets before fabrication. (CM uses a fixture which bends the material about 140 deg over a 1t radius. The strain rate used is 19 in. per min. Some sheets have been produced with this test with a transition temperature well below 70 F.)**
  - Rolling temperature and reductions must be carefully controlled in fabricating molybdenum to give uniform properties throughout the sheet.
- **A new research program is under way on the rolling of molybdenum-titanium alloy sheets . . . taking into consideration various reductions, recrystallization, and stress-relieving temperatures . . . and another to explore the effect of ingot quality on the properties of the final molybdenum product.**

Table 2 — Physical Properties of Molybdenum

Atomic Number	42
Atomic Weight	95.95
Lattice Type	Body centered cubic
Density, lb/cu in.	0.368
Melting Point, F	4720 ± 18 F
Boiling Point, F	8670 F
Specific Heat, cal/gm/C	
50 C	0.06
500 C	0.07
Heat of Fusion, Btu/lb	126
Heat of Sublimation, Btu/lb	2880 × 10^{3}
Heat of Combustion, Btu/lb	3261.6
Coefficient of Thermal Conductivity, Btu/ft^{2}/ft/hr/F	
Room Temperature	76
400	71
800	66
1200	63
1600	60
1800	58
Mean Coefficient of Thermal Expansion, in./in./F × 10^{-6}	
Temperature Range	Mean Coefficient
32/200	2.67
32/1000	2.98
32/1600	3.21
32/2000	3.36
32/2600	3.59
32/3200	3.81

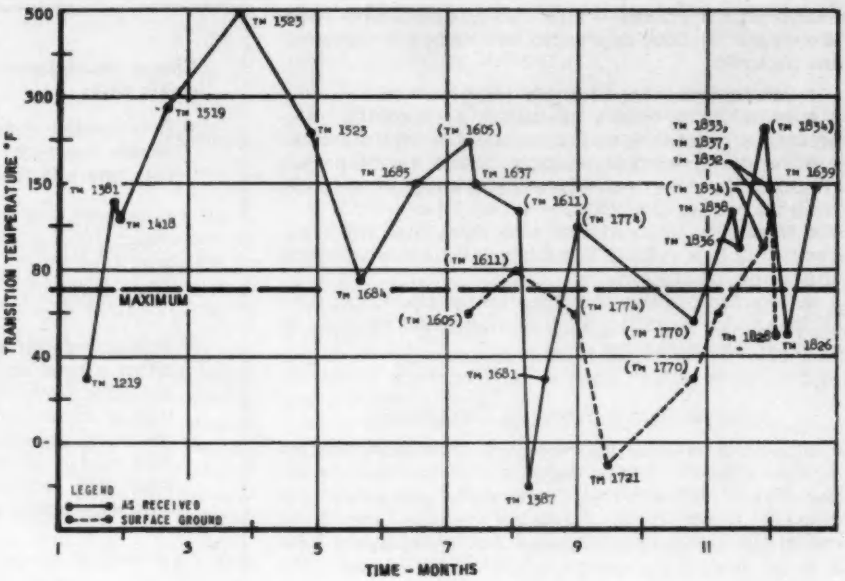


Fig. 3 — Bend transition temperatures for as-received and surface-ground 0.5% Ti-molybdenum alloy sheet for 1958.

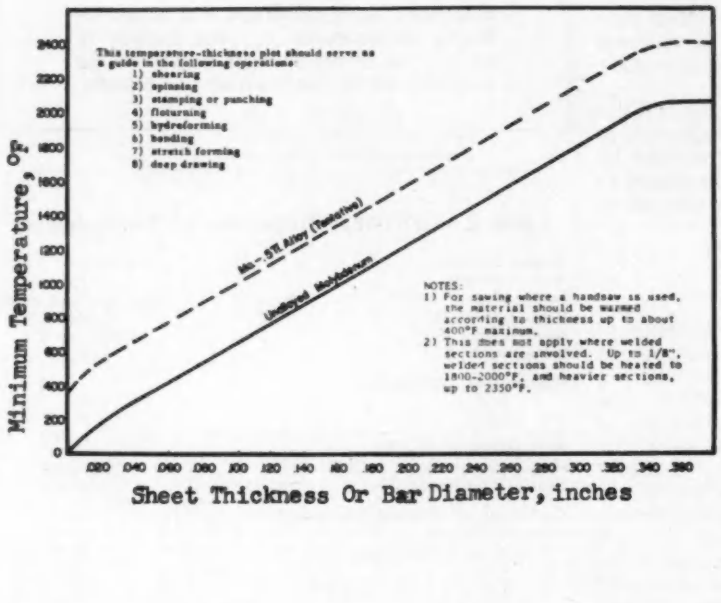


Fig. 4 — Suggested minimum working temperatures for molybdenum and Mo-0.5 Ti shapes.

Fig. 5 — American Standard and Acme threads machined in molybdenum tubing.

MOLYBDENUM—

continued . . .

ductions between anneals or stress reliefs on hot cold worked material should help the molybdenum alloys now being produced.

Laminations certainly are not desirable. However, one can live with them.

45-Deg Preferred-Angle Cracking

Molybdenum sheet metal exhibits an anisotropic property in its tendency to propagate cracks at very fast rates in a direction that is 45 deg from its rolling direction. This behavior is extremely intermittent in nature. But it is particularly harmful because of the apparent extreme ease with which the cracks can traverse great distances. The differences between transverse and longitudinal and even 45-deg tensile properties give no clue as to the presence or cause of the 45-deg cracking. It can often be prevented from occurring by not introducing sharp stress concentrations into parts.

Recrystallization

The properties of the solid-solution-type alloys being produced in refractory metals are enhanced only by introducing cold work into the sheet during its last rolling reduction and after the final annealing treatment. The ultimate tensile strength of the ½% Ti-molybdenum alloy can be increased from 33,500 psi to 74,000 psi at 2000 F by cold working. If the recrystallization temperature is exceeded either in service or in processing (such as in a coating operation), this marked strength increase is lost.

Creation of new alloys with recrystallization temperatures above 3000 F is an important future step that is being taken in the laboratory.

Fabricability

The fabrication of powerplant and missile components from commercially pure molybdenum and 0.5% Ti-molybdenum alloy has been accomplished by all of the commonly used fabrication techniques.

But, because of the lack of room temperature ductility, all handling, forming, and joining must be done at elevated temperatures.

Shop personnel must be trained to handle the material properly and to respect its ambient temperature limitations. The result of extensive fabrication and coating development work at Marquardt recently culminated in fabrication of an all-molybdenum-riveted and oxidation-protection-coated tailpipe.

Sectioning

Molybdenum sheets can be sectioned by shearing and sawing when the porper precautions are taken. Machine shearing is done by heating the entire sheet to several hundred degrees Fahrenheit and then locally torch-heating the area to be sheared to between 400 F and 1000 F. A tempil-stick is adequate for a temperature measurement.

In hand shearing, such as on a Beverly Hand Shear, the material should be locally heated to a dull red (about 1000 F,) immediately ahead of the shear blade before cutting. By heating to these temperatures, the sheet will be well above its brittle to ductile transition range and cracking and opening up of laminations will be eliminated.

By using a fine-tooth blade at very high speeds on a band saw, flat patterns and formed molybdenum sheet sections can be cut. The creation of a heat zone immediately ahead of the saw blade as a result of friction caused by the high speed eliminates cracking in the material. Care should be taken to properly join the saw blade to avoid any shock associated with misaligned joints. An abrasive cut-off wheel with coolant also can be used to section molybdenum sheet.

> **COLUMBIUM-BASE ALLOYS also are beginning to show specific compositions that are completely ductile below room temperatures. While 0.5% Zr and 0.4% Zr columbium alloys are considerably below the strength levels of the best aluminum alloys, current development work gives promise of higher strength, completely ductile materials in the future.**
>
> **Rapid development has taken place in columbian-base alloys such as those mentioned, in 40% Ta alloy, and in the new GE alloys designated F44 and F48.**

Forming

The basic technique required to form shapes is primarily dependent upon the ability to control forming temperature as related to forming speeds and sheet thickness. Fig. 4 gives the suggested minimum working temperatures for molybdenum and 0.5% Ti-molybdenum alloy. The above relationship can be used as a guide. But, in some cases, experience and "feel" for the material must be utilized to form a part successfully.

In general, as long as molybdenum sheet is formed at elevated temperatures, it is as formable as any other sheet metal alloy and can be formed into complex shapes accurately.

Joining

Sheet metal assemblies incorporate joints of several types in their fabrication. Mechanical fasteners (screws, bolts, and rivets) have been pro-

MOLYBDENUM—

. . . continued

duced and welding techniques for resistance, fusion, and flash welding are being developed.

Mechanical Fasteners

An accelerated mechanical fasteners development program was initiated at Marquardt early in the molybdenum application program to fabricate rivets, bolts, and screws and to use them in joining molybdenum components.

To install rivets successfully, they must be heated to 1000–1200 F. Care should be taken to keep the metal component being joined at several hundred degrees Fahrenheit to insure that the base metal will not crack when the rivet is squeezed. Bolts can be installed at room temperature.

Care must be taken, however, to align bolt holes perfectly because any excess torque due to interference will shear the bolt before the threads will deform.

Bolts and screws can be coated for oxidation resistance prior to assembly, making allowance for the coating thickness. Riveted joints have been successfully oxidation-protection-coated after assembly.

Machining

For most machining operations, molybdenum cuts like the stainless steels. A carbide-tipped tool should be used.

When sheet edges are machined to prepare them for welding, mild steel bars should be clamped on each side of the sheet to prevent chipping and separation of the planes of weakness. In the chasing of threads, the material machines like cast iron. Powdery, discontinuous chips are produced. Fig. 5 shows American Standard and Acme threads machined in molybdenum tubing. For drilling and boring operations a chlorinated cutting oil should be used so that the chips can be continuously flushed from the hole because their abrasiveness can significantly decrease tool life.

Coatings for Oxidation Resistance

The greatest handicap of all the refractory metals, molybdenum included, is inability to resist oxidation at elevated temperatures.

The refractory metals, other than molybdenum (such as tungsten, tantalum, and columbium) form an oxide scale on the surface when exposed to an oxidizing atmosphere at elevated temperatures. However, above about 1000 F molybdenum volatilizes as molybdic oxide (MoO_3) and the rate of this phenomenon increases rapidly as the temperature increases.

At about 1400 F the rate of volatilization equals its rate of formation. Fig. 6 shows the loss in thickness from oxidation of molybdenum sheet exposed to air on both sides at elevated temperatures.

At 1800 F, the oxidation rate for molybdenum in slowly flowing air is greater than 0.022 in. per hr per surface. To overcome this serious disadvantage, much research has been done on the development of coatings for the oxidation protection of molybdenum.

Hot dip, paint and sinter, flame spraying, electroplating, electroless plating, electrophoretic deposition, vapor phase deposition, flame plating, cementation, and cladding coatings have been developed.

To Order Paper No. 56T . . .
. . . on which this article is based, turn to page 6.

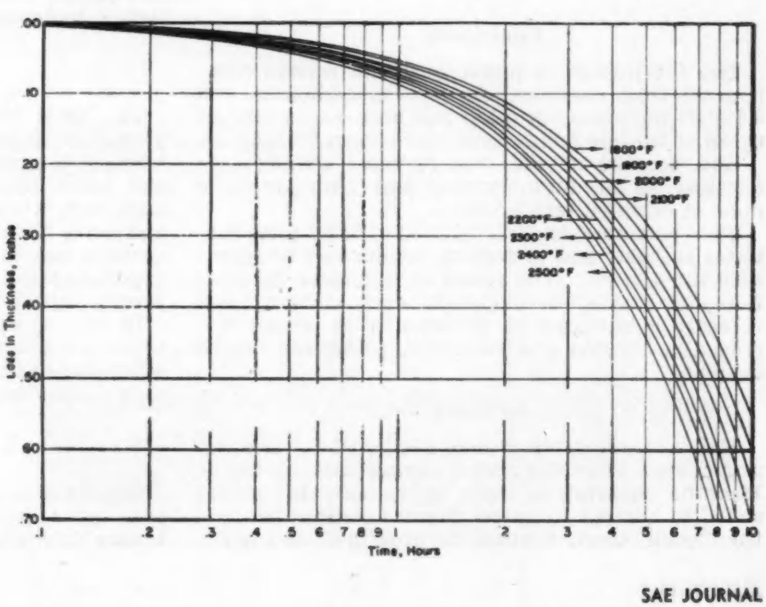


Fig. 6 — Total loss in thickness from oxidation of molybdenum sheet exposed to air on both sides.

New Welding Processes

Better Weld Quality

for Less Dollars

Based on paper by

John J. Chyle

A. O. Smith Co.

NEW WELDING PROCESSES are dropping costs while providing improvements in weld quality. This article describes some of the more promising new developments in pressure welding and fusion welding.

Pressure welding

Pressure welding uses force as the primary element in obtaining the coalescence of metal. The force usually is applied over the entire area of the abutting surfaces and the coalescence may be produced either with or without the application of heat.

Ultrasonic welding

Ultrasonic welding uses elastic vibratory energy in the joining of metals. Both spot and seam welding of metal sheets can be accomplished using commercially developed equipment.

Fig. 1 is a sketch of the component parts, and consists of a transducer and a coupling system which is incorporated to a vibratory element or electrode. The weldment is inserted between the electrode tips as shown.

Another form of ultrasonic welding is the continuous seam welder shown in Fig. 2. With this equipment ultrasonic energy is applied continuously to produce a pressure tight welded seam. Thin foil as well as light sheet metal can be welded. Both of the rollers shown are powered, and rotate to provide the desired traversing speed of the sheets to be welded. In some designs the welding head rotates and traverses along a fixed workpiece. In other designs the welding head rotates while remaining in a fixed position and the workpiece travels on a moving fixture under the rotating welding head. Metals difficult to weld by conventional methods can often be joined with this process, such as stainless steel, molybdenum, zirconium and its alloys, inconel, tantalum, and titanium. Ultrasonic welding is also used for the joining of dissimilar metals such as brass, copper, steel, and aluminum to zirconium; platinum, molybdenum, brass, inconel, and silver manganese to various steels; titanium, copper, gold, and platinum alloys to nickel; copper and silver to brass; copper, molybdenum, and tantalum to aluminum; and platinum and ruthenium alloys to a silver-gold alloy.

With further developments in the equipment for ultrasonic welding it is expected that the allowable material thickness will be extended, and that the applications for this process will be expanded.

High frequency resistance welding

High frequency resistance welding is one of the newer welding processes which depends on high frequency electrical energy to obtain the desired heating characteristics for welding. Alternating current of 100,000 cps or more is connected directly to the work to be heated by means of contact electrodes.

The contacts are placed on each side of two abutting surfaces of metal (Fig. 3). The edges touch at one end and the rest of the joint is open slightly so as to form a *V*. The current flowing into one contact hugs the edge surface of the *V* as far as the root, and completes the circuit by returning along the opposite edge of the *V* to the second contact. This skin effect produces localized high intensity heating, so that the edges at the root of the *V* reach welding temperature at the same rate that the tube progresses through the welding machine. Pressure applied at the root of the *V* brings the two edges together in a forge weld. Travel speed of the tube

New Welding Processes

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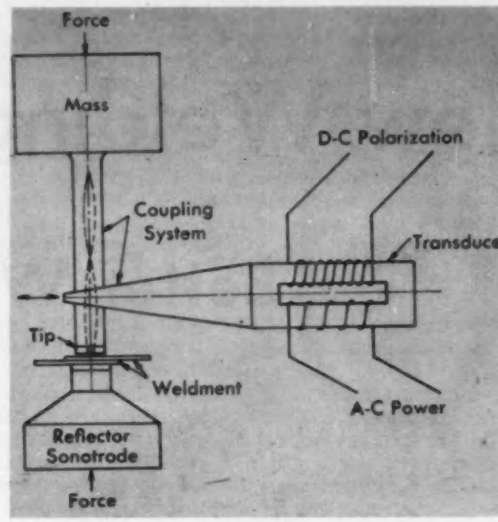

Fig. 1 — Essential mechanism for ultrasonic welding.

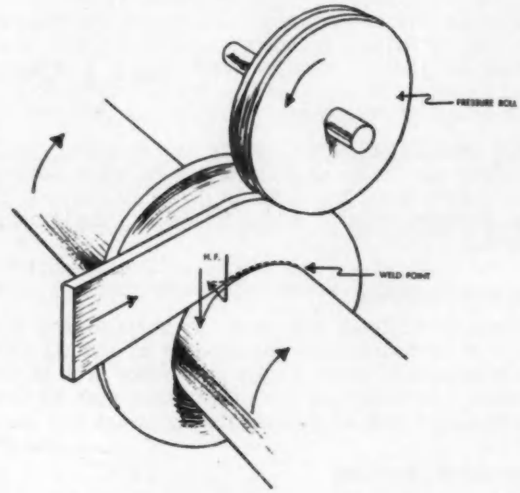

Fig. 4 — Spiral fins can be welded to tube with the high freqency welding process.

is up to 200 fpm, depending upon the thickness of the wall.

The process is applicable to a variety of metals, such as aluminum, brass, copper and copper alloys, stainless steels, silicon bronze, monel, inconel, and incaloy. Some of the highly reactive metals such as titanium, titanium alloys, and zirconium alloys have been successfully welded with this process, using inert gas for shielding. Combinations of dissimilar metals also have been successfully welded.

One of the advantages of this process is the high speed that can be used. Speeds up to 1000 fpm have been obtained with light gage materials. The process is not limited to tubing, but can be applied to such shapes as strips and *T* sections. Spiral strips of metal can be welded to the surface of tubes as shown in Fig. 4.

High frequency resistance welding, by utilizing high power density, results in greater speeds, wider versatility, and has great potentials for applications where high production, high speed welding is important.

Foil seam welding

Foil seam welding was developed in Europe, and has found application where high speed welding and freedom from distortion are important. It is a resistance welding process for making butt-type joints in flat strips or sheets. Thin foil strips 5/32–3/16 in. wide and 0.007–0.010 in. thick are placed at the top and bottom surfaces directly over the square abutting edges (Fig. 5). A small nugget is formed which gradually increases in width (see sketches). And, the thin foil strips are pressure welded into the fused area (section D-D). Welding speeds run 3–24 fpm on 0.087 in. stock. And the process provides an end result which is relatively free from distortion, with the joints being flat and requiring little, if any, final dressing of the weld metal.

The foil seam welding process has future potentialities because of its lower finishing costs and dimensional uniformity.

Magnetic force welding

Magnetic force welding allows accurate synchronization of the electrode force and the welding current. This is brought about by coupling the electrode force or pressure with the magnetic force created by the welding current.

The magnetic force welder is generally a conventional direct-acting piston or ram type spotwelder which has been redesigned to accommodate electromagnets for the application of pressure (Fig. 6). The air cylinder actuates the ram for positioning of the weldments between the electrodes and also imposes a slight initial pressure on the work prior to welding. Final force of the weld is controlled by the gap set by the ram collar. Some combinations of materials need a longer heating period before welding, and for this a d-c magnet acts to delay forge pressure application. In most applications, the welding time is small, varying from one-half to a few cycles.

The magnetic force welding process can be used for welding high conductivity metals to each other, and also to carbon steels. Better uniformity and consistency of welds is obtained resulting in improved electrical characteristics of contact-type joints. Expensive bi-metallic contact points can

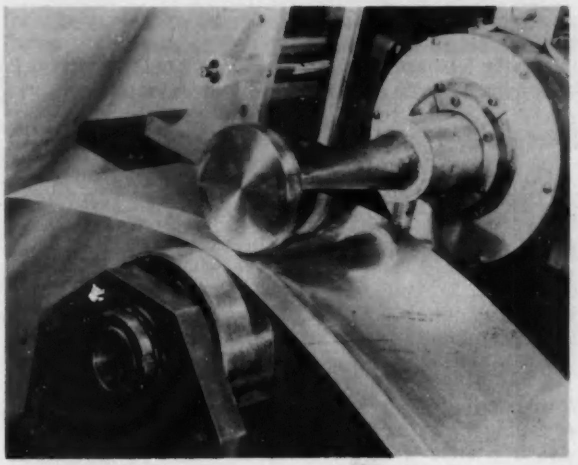

Fig. 2 — Continuous seam welds can be made with ultrasonic seam welding equipment. The ultrasonic energy is delivered continuously through the disc tip as the work travels between the active disc and the base roller.

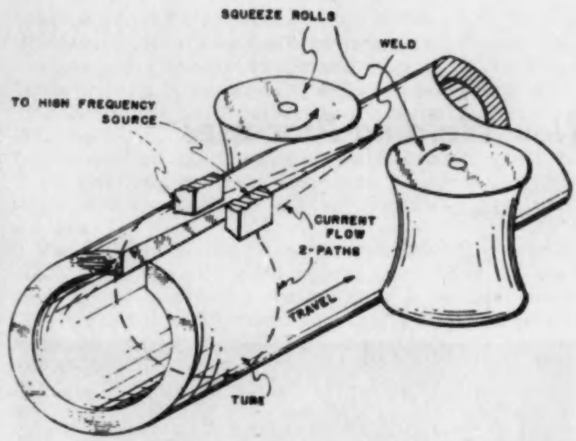

Fig. 3 — High frequency resistance welding equipment for tube welding.

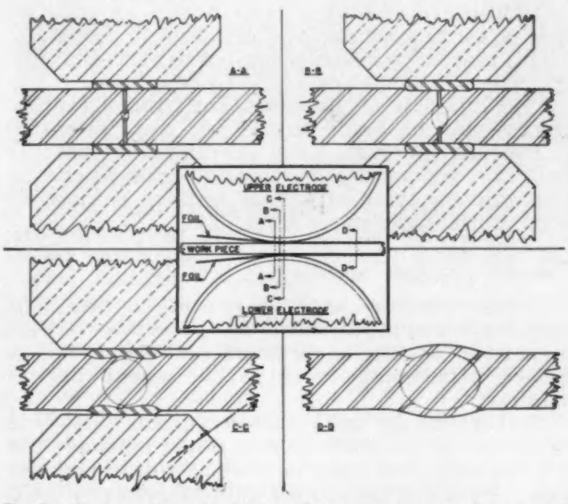

Fig. 5 — Sketches show the position of component parts and progress of fusion with the foil seam resistance welding process.

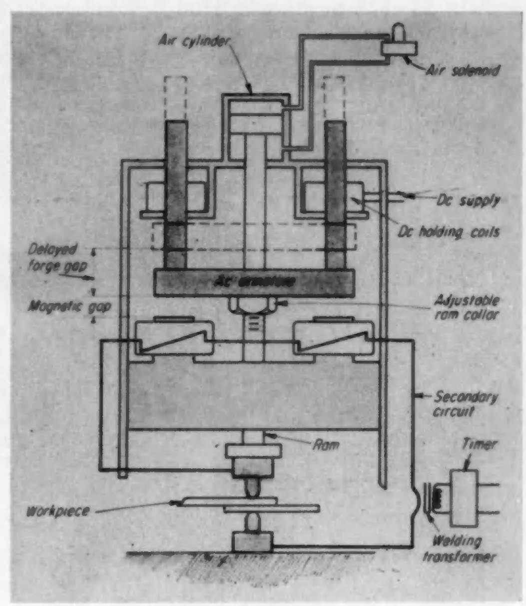

Fig. 6 — Magnetic force welder.

be substituted for by less expensive points joined by magnetic force welding at savings up to 50%.

Percussion welding

Percussion welding is a newly developed resistance welding process in which the weld is made in an exceedingly short period of time over the entire area of the metals to be joined.

The weld can be produced either by a rapid discharge of electrical energy from a stored energy type of power source, or by the rapid dissipation of current with a standard 60 cycle a-c source. The part to be welded has a small pinpoint type of projection formed or coined into the part which is vaporized upon contact with the downward moving electrode. In the stored energy type of equipment, an air cylinder controls the rapid movement of the electrode. In the resistance spotwelder, the magnetic force created by the welding current is used in the rapid movement of the electrode, and the welding time is usually one-half cycle in duration.

This process produces high quality welds over large contact areas and this can be done with the

New Welding Processes

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smaller capacity machines. Another advantage is the welding of dissimilar metals for high conductivity electrical contact points, with resultant improvements in finishing and appearance.

Friction welding

Friction welding is an operation based on heat produced by friction of rapidly moving parts under high pressure. The heat obtained is sufficient to cause fusion or bonding of the metal parts.

Chucks hold the parts in line with the horizontal axis (Fig. 7), one part rotating while the other is held stationary. Pressure is applied which generates sufficient heat so that fusion of the parts takes place.

After the fusing temperature is reached, rotation is stopped with the pressure being maintained or sometimes increased, until the completion of welding, after which the weld is cooled in air. Total welding time for some parts runs 10 to 25 sec, and the energy that is consumed may run only 10% of that required for a similar weld fabricated by flash welding.

In this process, foreign materials such as scale and impurities are removed by friction and plastic deformation of the joined pieces. Many materials have been welded using this process — low carbon, medium carbon, and free machining steels, stainless steels, cast iron, brass, aluminum, and titanium, in addition to dissimilar metals such as brass to steel, brass to cast iron, and cast iron to copper.

This process is presently limited to parts that are cylindrical in shape and that can be rotated.

Some inherent advantages of the friction welding process may be found in the low cost power requirements and high speed operation. It has interesting possibilities for special applications to production welding of simple sections because of lower initial investment costs.

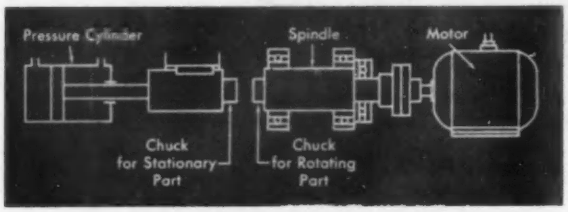

Fig. 7 — Equipment for friction welding.

Thermo pressure welding

Thermo pressure welding can be considered a solid phase welding process. The parts to be welded are under continuous pressure and the metal is heated until complete or partial plastic flow is obtained.

The success of this process depends upon the cleanliness of the surfaces held under pressure, and the application of heat to produce a true pressure weld. With the thermo pressure welding process it

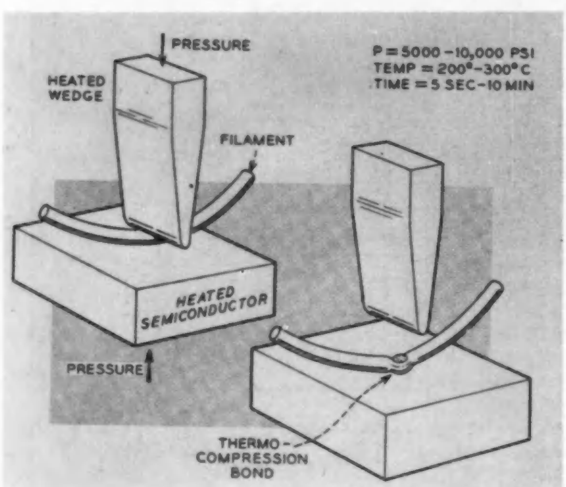

Fig. 8 — Position of parts for thermo pressure welding.

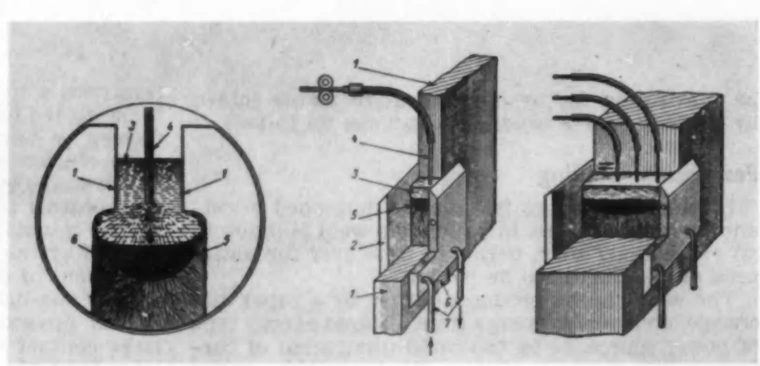

Fig. 9 — Electro-slag welding process — left: cross-section of weld; center: vertical weld made with single electrode; right: vertical butt joints in heavy plates may require more than one electrode.

is possible to weld metals to semi-conductors and to other metals which would be difficult to weld by fusion welding processes.

Fig. 8 shows the attachment welding of filiment wire to a heated semi-conductor by the application of pressure. Pressure may range from 5000 to 10,000 psi and heating temperatures may range from 200–300 C. The duration of pressure application is important in this process and may vary from 5 sec to 10 min.

The thermo pressure weld process has been used in the joining of semi-conductors to metals like germanium and silicon. This process may solve many of the problems in making contacts to small areas without using chemical fluxes and melting in the fabrication of transistors and other semiconductor devices.

Diffusion bonding

Diffusion bonding is a joining method in which metals to be joined are heated to temperatures below their solidus temperature and are held under pressure for some length of time. No liquid phase is formed and the bonding occurs by movement of atoms or intermetallic compounds across the interface on the surfaces where contact occurs.

For some of the diffusion bonding operations a plating of nickel, gold, copper, and other metals is first deposited on the surfaces to be joined. After the plating operation the parts are joined by applying pressure and temperature. Diffusion bonding temperatures are generally below 1000 F and pressures range from 4000 to 8000 psi. The time required for diffusion bonding varies, depending on the metals to be joined, and may extend from 20 min to 3 hr.

Metal combinations which have been diffusion bonded include: gold and copper; gold and silver; nickel and copper; aluminum and gold; gold and nickel; and iron and nickel.

Interface surfaces must be kept clean. These must be prepared to obtain smooth and uniform contact. During the bonding operation, it may be necessary to use inert gas to prevent oxidation of the bonding surfaces.

Diffusion bonding may be used to weld some special alloys where conventional welding processes are not suitable. Since the temperatures are low, previous heat treatment may not be affected. And, distortion and cleanliness can be controlled.

Fusion welding processes

Fusion welding refers to a group of related processes using heat to obtain coalescence of metal. Heat sources include electric power, chemical reactions, combustion of gases, and solid fuels.

A number of new processes in fusion welding have been developed which appear to hold promise for future applications.

Electro-slag welding

One of the most recent developments in fusion welding is electro-slag welding. Fusion of the electrode wire and the parent metal takes place in and under a molten slag bath covering the metal bath from which the weld is formed (Fig. 9). The electrode wire or wires are immersed in the liquid slag. The process is used primarily for welding plates of 2 in. to 12 in. thickness or more. The process can be readily adapted welding vertical butt joints in heavy weldments, girth seams in heavy wall cylinders, and for building up large surfaces and weld deposit.

Fig 9 (left) shows the cross-section of a weld in which a single electrode wire is used. Fig. 9 (center) shows the setup for making a vertical weld. The arc is initially established under the flux, which melts the flux and raises its temperature to a point where arc action is terminated and current is conducted through the molten flux. The resistance of the molten flux to the flow of current creates the heat necessary to melt the wire. The weld metal is obtained from the melting of the electrode wire in the superheated flux, and is deposited as a molten puddle of metal which settles below the molten flux.

For making vertical butt joints in heavy plates, a number of electrode wires can be used simultaneoully (Fig. 9-right). The wires can be oscillated back and forth so that the weld is uniformly deposited throughout the entire groove section. For making vertical butt joints, the ends of the groove are enclosed by water cooled copper plates so that the slag is confined to the weld area. These plates are moved upwards as the deposition of metal progresses.

This process provides a metal deposition rate which may run as high as 45 lb of weld metal per hour.

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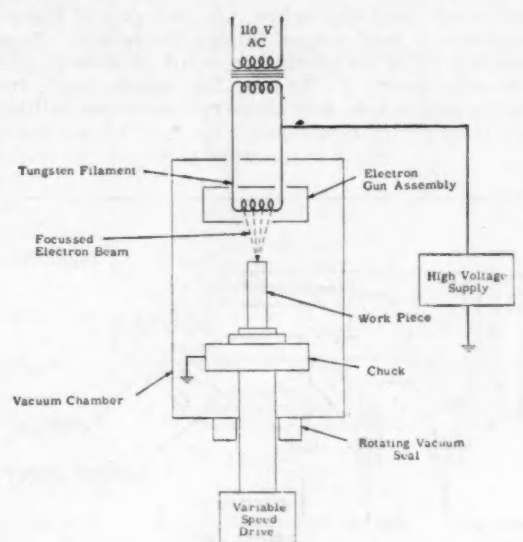

Fig. 10 — Diagrammatic sketch of the high vacuum electron beam welder.

New Welding Processes

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The Russians are said to have welded carbon steels, certain types of low-alloy high-strength steels, and stainless steels with this process.

Two limitations of this process are: a large heat affected zone adjoining the weld, and a coarse volumnar structure of weld metal deposit. Recommendations have been made to heat treat the weldments by a normalizing type of postheat treatments to refine the grain structure. On every large weldments this would be costly, and problems of distortion would have to be considered.

Electron beam welding

Electron beam welding is based on the impingement of electrons on the workpiece under high vacuum conditions (Fig. 10). The electrons are emitted from a tungsten wire filament, and are given a high degree of acceleration and velocity by a high voltage potential between the cathode and anode, the electrons moving from cathode to the anode. The workpiece is the anode.

Concentration of the electron beam on the workpiece is controlled by either magnetic focusing or electrostatic focusing devices. The part to be welded is on a work table or stage which can be moved to direct the welding beam to the welding area.

Because a high degree of vacuum is necessary to obtain electron bombardment, there is no contamination from the oxygen or nitrogen of the atmosphere or from other foreign materials. Since operation from an electronic point of view is possible only below 2×10^{-4} mm Hg, atmospheric impurities amount to less than one part per million. Such high purity represents a distinct advantage of this process over any other welding method developed to date. In addition, the high temperatures of the process tend to vaporize some of the impurities in the parent metal, with the result that the weld is cleaner than the original base material.

An outstanding feature of the process is its deep penetration. It is possible to obtain a depth of fusion ratio of 2 to 1, which implies a high temperature gradient. Weld quality is excellent, with freedom from porosity and slag inclusions. Mechanical strength and impact properties are claimed to be comparable or slightly better than welds made by the inert gas tungsten arc process. Grain size in the fusion zone and the adjacent heat affected areas is smaller for electron beam welds than for welds made by other fusion processes.

The following metals have been satisfactorily welded: tungsten, molybdenum, beryllium, tantalum, zirconium, and hafnium. The process can also be applied to carbon and stainless steels.

One disadvantage of this process, however, is that when operating at the very high voltages x-rays are emitted which require shielding protection for personnel.

Arc plasma

One of the newer achievements has been the development of arc plasma heating which produces temperatures ranging from 10,000 to 30,000 F. The basic principle consists of passing a gas — usually an inert gas, although nitrogen and hydrogen can also be used — through a chamber in which an arc is maintained. The flow of electrons from the cathode to the anode ionizes the gas and the resultant bombardment causes the gas to be heated to extremely high temperatures. The passages in the arc torch are constricted so that the walls of the torch, which are water cooled, do not become hot. The ionized gases are forced through a nozzle opening so that the heated gases have the appearance of a flame emanating from the end of the chamber.

Fig. 11 is a sketch of an arc plasma torch. The electrode and nozzle are connected through electrical current connectors to a d-c source. Gas is fed into the nozzle inlet. An electric arc is struck between the electrode and the nozzle by means of a high frequency current. Gas around the electrode point constricts the arc giving it an umbrella shape. Gas flows around the electrode and through the umbrella arc, emerging as a plasma flame of 10,000 to 30,000 F. Water flows through the jacket to cool the torch. Electrical cables are placed inside water hoses, and hence water cooled. An overall thermal efficiency of 60% to 80% is obtained.

Arc plasma has been developed primarily as a source of heat, and while some equipment has been developed for metal and ceramic material deposition, the process has great potential for future applications for fusion welding of metals.

One limitation of the process is the high pressure blast effect that is developed in the arc plasma causing the liquid molten metal to be blown away from the weld area.

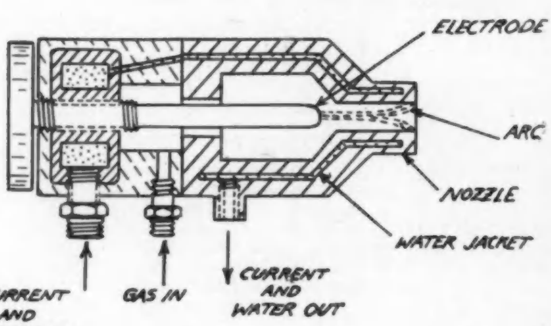


Fig. 11 — Arc plasma torch.

To Order Paper No. 52S . . .
. . . on which this article is based, turn to page 6.

Used oil analysis

What does it tell?

Based on paper by

T. H. Madden and W. R. Tuuri

Standard Oil Co. (Ohio)

Abridgment of an **SAE Cleveland Section Paper**

SAMPLES of used oil can be analyzed to identify and measure contaminants in the crankcase oil. These unwanted products may come from the fuel, the cooling system, the air, metal parts of the engine, or from oxidation of the oil itself. Any contaminant in an excessive amount indicates some mechanical problem, or depletion of the oil additives which may cause severe mechanical damage.

Table 1 tells what the contaminants are, the damage they do, and how to identify and measure them.

One of the greatest hazards to truck fleet operators is the leakage of glycol antifreeze into an engine. The antifreeze can polymerize to seize an engine by forming a sticky, tacky coating which is insoluble in the oil. Its detection in the crankcase, or leaking from the cooling system, needs to be prompt.

The emission spectrometer is a thoroughly practical tool for used oil analysis. Preparation of the sample for testing is simple and direct. There is no need to separate the insolubles from the oil by centrifuging and solvent treatment. A small sample is taken directly and reduced to ash, then analyzed for its metal content. The whole process can be completed in less than a minute.

Infrared absorption can be used to determine the presence of antifreeze in the oil, and excessive fuel contamination. It will tell when the oxidation inhibitor is spent, which signals the need for an oil change. It will tell the amount of detergent dispersant left in the oil, but it will not detect the presence of dust, dirt, and metals from the wear of engine parts.

Used oil analysis won't tell all. It will not indicate when exhaust valves are beginning to burn; neither will it tell when rings are worn from normal operation. But it can detect the generation of excessive bearing metal and, if sampling is done at reasonable intervals and complete records are kept, the impending failure of the engine can be predicted if the metal concentration increases abruptly. Analysis *after* failure will not disclose the cause.

To Order Paper No. S164 ...
... on which this article is based, turn to page 6.

Contaminants, the damage they do, and how to identify and measure them

Contaminant (Liquid)	Nature of Damage	Identification and Measurement
Gasoline Diesel fuel	Reduces oil viscosity	ASTM distillation test Determine % oxidation products, then loss of viscosity
Partially burned or oxidized fuel	Varnish or lacquer on pistons, valve stems	Infrared absorption
Water	Corrosion	ASTM distillation test
Antifreeze	[a]	Infrared absorption
Contaminant (Solid)		
Carbon, oxidized fuel, and oil	Varnish and lacquer	Infrared absorption
Sand, dust, dirt	Wear of pistons, rings, and bearings	
Metal wear debris (iron, lead, tin, chromium)	Excessive quantities indicate failing of vital engine parts	Emission spectroscopic analysis
Inorganic salts	Not detrimental	

[a] Glycol antifreeze can polymerize and seize an engine by forming a sticky, tacky coating, which is insoluble in oil.

Fig. 1 — Thin airfoil with flap.

4 Ways to Improve Jet Take-off & Landing

Install:

• Leading-edge, high-lift devices.

• Direct-lift engines to give VTOL capabilities.

Our Too Short Runways!

FOR a variety of reasons, the author points out, we don't have enough runway length around the country to operate the new jets properly.

What can the airlines do about it? Here are some possibilities:

• They can either restrict loads or not offer services that the aircraft are potentially capable of performing because of inability to operate safely at the limited weights allowed.

• They can ask for the elongation of many important runways. This phase would take a little longer and, in some cases, could not be accomplished at all without abandoning some existing airports.

• Somewhat down the line, they can attempt to have the aircraft modified, either on a new or a retrofitted basis.

It is on this last point that the author elaborates in the accompanying article.

Excerpts from paper by

F. W. Kolk
American Airlines, Inc.

HERE are some possibilities for shortening the field length requirements of our jets:

• Install leading-edge, high-lift devices, which are retrofitable to present-day aircraft.

• Retrofit — or purchase new — aircraft powered by turbofan engines. These have an inherently higher take-off thrust to cruise thrust ratio than the jets, which vastly improves the take-off acceleration.

• Use boundary-layer control actuated by turbine discharge gas for immediate consideration in new aircraft designs.

• Further down the road, use direct-lift jet engines. They will improve the block speed characteristic of the aircraft and also give vertical take-off and landing capabilities.

Leading-edge, high-lift devices

Over the years we have seen a gradual increase in the usable $C_{l_{max}}$ through the use of better flaps, until such time as flight speeds entered the compressibility region. Since then, anything done to improve the high-speed characteristics of a wing reduced its maximum lift. From a take-off and landing viewpoint, our wings are decidedly less effective in the newer, faster aircraft. Moreover, with the thin wings required for good, high subsonic operation, the resulting sharp leading edges cause premature stalling of the forward upper surface. (See Fig.

Fig. 2 — Leading-edge slats.

- **Turbofan engines.**

- **Boundary-layer control.**

1.) This can be cured by camber, but such camber tends to ruin the high-speed ability of the airfoil. The answer is the use of leading-edge devices, such as drooped lead edge, Kruger flaps, slats, or slots. (See Figs. 2 and 3.) Curiously enough, such devices are the rule rather than the exception on military aircraft but, until recently, their use on commercial vehicles was not even considered.

There is now some indication that the well-dressed transport will sport her slats or other leading-edge device, and will thereby benefit by increased lift, decreased drag, and ability to fly safely very much closer to the stall than has been possible up to now. Already the Boeing 707-120 series is equipped with a short section of Kruger flap, just inboard of the outboard strut, and her younger sisters of the 707-020 series will be far more generously endowed. The Douglas DC-8 is flying with a slot arrangement and the Convair 600, the big sister of the 880, will sport slats on most of her leading edge. These things shorten the take-off and landing distance.

Turbofan engine

Either take-off or landing distance can be critical, depending on the distance to be flown and the characteristics of the individual aircraft model dealt with. Generally, it is the take-off distance that limits the operation aircraft. Therefore, we must look particularly for ways and means of attacking this phase of the problem — keeping in mind that landing might become critical if take-off is improved very much. There is one possible retrofit that reduces the take-off distance without affecting the

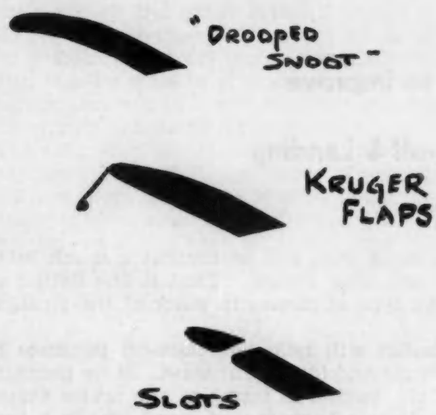


Fig. 3 — Leading-edge, high-lift devices.

Fig. 4 — Boundary-layer-control system being used to control separation occurring on rear upper surface of highly cambered airfoil.

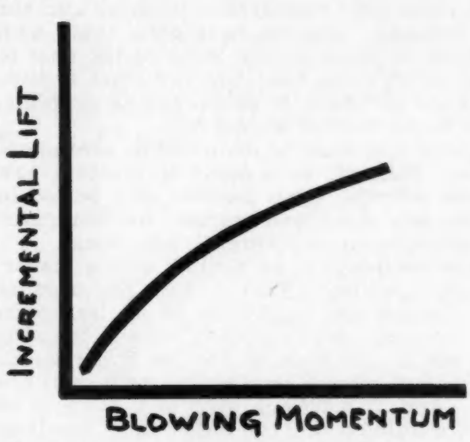


Fig. 5 — Curve showing effectiveness of BLC system. Note that first little bit of air does a lot of good but incremental effectiveness falls off rather rapidly as greater and greater force is applied to system.

landing distance that will be becoming much more popular in the near future. That is the fitting of the turbofan type of engine in place of the straight turbojet.

The turbofan will help the take-off distance in two very simple and important ways. If we measure the size of the engine in terms of the cruise thrust at altitude, then a turbofan of equal size to a turbojet will have more take-off thrust. It will, therefore, have a greater take-off acceleration. The ratio of this increase in thrust for take-off is on the order of 20% in the engines currently being offered. We can expect that the distance required to take-off at a given gross weight will be reduced by a factor of the order of 20%. At the same time, the turbofan is a considerably more efficient powerplant in cruise than the straight turbojet, and the specific fuel consumptions will, therefore, be somewhat lower. Because of the lowered fuel consumption, the take-off weight will be reduced to fly the same distance; and in aircraft of this type, for every per cent that the weight is reduced, the take-off distance will be reduced by about 20%. Thus, for fairly long ranges, the turbofan aircraft will require 65–75% as much runway as the turbojet aircraft to do the same transportation job.

In our opinion, this gets to the end of the road for the present aircraft on a retrofit basis. Anything beyond the installation of turbofan engines and leading-edge, high-lift devices is difficult to conceive as a retrofit, without prohibitive costs. Anything else will require at least new production machines.

Suppose now, that we have gone as far as we can down the road of retrofit, and we have substantially reduced — that is, 10–30% — the take-off distances, and have made some considerable progress with the landing distance. And we have gone along with our program of fixing up the worst of the dogs of runways. Everything fits. The situation is then like the state of affairs in piston-engine operation just prior to the dawn of the Jet Age.

The equilibrium could be disturbed by several developments. First off, in a desire to create a new market for aircraft, some builders may be led to invade the very short field market now dominated by the propeller-driven aircraft with small jets. This means the design of jet aircraft with an honest field length capability of 4500 ft. Such performance is clearly beyond the capabilities of jet transports as now conceived. As it stands at present, the wing loadings are far too high for the low flying speeds for landing and take-off required for such short operations. And, if sufficient wing area were to be used, the resulting riding comfort in mild, low-level turbulence would pretty well debar the use of this class of vehicle. What we need is to be able to raise the wing loading and at the same time lower the stall speed.

The answer to this type of vehicle seems to be boundary-layer control for the development of lift.

Boundary-layer control

BLC, as it is referred to, can be used either to increase the lift of a surface or to decrease the drag of a surface. In either case, the desired result is achieved by reducing the tendency of the flow to separate as it encounters adverse pressure gradients. This is done either by sucking away the spent boundary layer or by revitalizing it by the introduction of high-velocity air at or near the point of separation. If the system is to be successful, it is necessary that the power required to eliminate the separation or to drive the system be less than the power saved in operating the equivalent vehicle without the BLC. As this is sometimes very difficult to prove, perhaps we should say that the BLC system is successful if the vehicle built and operated with it is a better vehicle than one not so equipped.

Any system to be used on a commercial aircraft must first be reduced to reasonably sound practice. This fairly well limits us to blowing systems designed to increase lift. All such systems blow air out of slots to increase the lift of the wing.

The mechanism is shown schematically in Fig. 4. In this case, the BLC system is being used to control the separation that occurs on the rear upper surface of a highly cambered airfoil. By so doing, the lift of the airfoil is considerably increased, and the drag is reduced — at least the profile drag is reduced.

The induced drag, if we have a finite airfoil, may get to a pretty high value if the lift is sufficiently increased.

We measure the effectiveness of the BLC system as shown in Fig. 5. The first little bit of air does a lot of good but the incremental effectiveness falls rather rapidly as greater and greater force is applied to the system.

Tests show that rather large lift coefficients are available to the aircraft designer by the use of such arrangements. Why do we not dash out and install them on our aircraft forthwith?

If we were in trouble on the landing requirement and just didn't have to worry about the take-off, I think that the answer would be fairly clear — we would have BLC on almost everything that has wings. In this condition, the engine is not required for acceleration except on a pullout, and is available as a source of power to drive the system. There is no net loss involved in this drive requirement. On the take-off however, if the engine is used as the means of acceleration of the vehicle up to flying speed, any power used by the BLC is going to come out of acceleration, unless some valving arrangements are made for cutting in BLC at breakground. Such valving may be beyond our present state of the art inasmuch as it affects aircraft control systems, engine control systems, and pilot technique. What a time to have an engine failure!

Actually, there has been some progress made with BLC for take-off. When people first started to build systems of this sort for jet aircraft, there was no net gain in take-off distance. Now some systems have been built where the take-off distance is actually somewhat shorter with the BLC system on than off. The reason for this rather poor luck with the BLC

installations is that they have depended on the bleeding of compressors to get the high-pressure air for the blowing system. When this is done, 2–3 lb of thrust will be lost from the engine for every pound of thrust that is applied to the BLC.

Why has BLC not lived up to its expectations in commercial vehicles? To start out with, most serious applications of BLC have been on jet aircraft and, in each case, the air for the blowing system has been made available through the process of compressor bleed. The application of this system to a jet engine is very injurious to the resulting thrust of the engine. If we keep in mind that the BLC blowing system uses a jet of air blown out over the flaps to achieve its results, it would seem quite obvious that this jet of air is available — at least during the ground acceleration, for thrusting the aircraft — and that when it is doing its work as a lift augmenter it has to overcome the additional induced drag of the regime plus some entrainment losses. Clearly, it is not going to waste. If we take a pound of thrust away from the jet and reapply it to the trail edge of the wing, we should be paying Paul even if we are robbing Peter. Of course, because of duct losses and poor nozzle coefficients and temperature losses, we cannot hope to get the same energy recovery out of the blowing slots that we got from the main jet, but it should let us have ample room to work out a system.

However, that isn't the way these things get built. When the compressor is bled to get the blowing air, for every pound of momentum we can theoretically produce in the blowing jet, we have robbed ourselves of 2–3 lb of thrust from the engine. If we add system losses to that, it is quite evident that any major reduction of stall speed will entail a very major reduction in acceleration. Thus, we come to a basic conclusion, namely, that the BLC system must be so integrated with the powerplant that the most efficient compromise of arrangements is used.

But we cannot stop here, as we have not yet come to grips with the knotty part of the problem. The BLC system is an airworthiness item to the transport aircraft. It cannot be subject to loss of performance or control due to failure of a powerplant. And if we get our air from a powerplant, the system must be designed to function with a powerplant suddenly made inoperative at any point during the take-off and at any speed that is likely to be encountered during the take-off. In short, it must comply with T-category. This means that, if the arrangements are such as to change the BLC jet force as a result of the failure of one or more sources of blowing power, this change must be symmetrical and the operating speeds of the aircraft should be selected so that there is ample margin above stall, even at the reduced flow. It would appear then, that a multiple source of blowing air must be used.

To me, this says that the real way to achieve BLC is to duct turbine discharge gases through the flaps blowing system, because this system produces the only minimum loss source of thrust for BLC. It further appears that the turbofan engine may be the best configuration of basic powerplant to supply this hot gas, because its gases are already somewhat cooler than those of the straight turbojet by virtue of the energy removed for fan drive. It would also appear that some form of variable-area exhaust nozzle is especially applicable to such a system, to make up for the gases being diverted to the flaps. Simple flapper-type devices can be used to account for system on or off and a second, smaller set of flaps can be used to compensate for the loss of an engine and can be controlled automatically. Thus, the engine can be made to operate on a single basic operating curve. In this way, it does not have matching problems as a result of system operation and produces BLC momentum efficiently. Its two disadvantages are the temperature of the gases in the pipe and the fact that the flaps will be black on such aircraft, regardless of the wishes of the exterior decor people.

There is a second benefit to be gained by the use of BLC during take-off. This arises out of the fact that we are now faced with an all-engine take-off requirement. Up until now, the engine-out take-off condition has been critical and the designers of aircraft have done all they could to bolster up this performance. One of the things done was the reduction of the wing incidence to as low a value as possible to make the brakes more effective. This feature, in connection with antiskid devices on the brakes, has made the braking action of the aircraft in a rejected take-off condition unbelievably good. At the same time, it has caused a real problem in rotation — especially in the all-engine take-off condition. Regardless of what you might hear about the rotation speed, and the speed gained during rotation, our last generation of aircraft didn't have this problem because they didn't have to rotate to take-off. The problem with the B-377, for instance, is to keep it from ballooning up off the ground too soon, a quite different condition from today's aircraft.

Actually, what is wanted is the ability, in effect, to vary the incidence of the wing, whether a take-off is being completed or rejected. And BLC does just this for us. When the engines are idled, the blowing stops over the flaps and the lift coefficient drops abruptly. Or, if you keep going, you get the effect of the higher incidence and lower rotation requirements at take-off. This could be a way of living with SR-422 and liking it!

Everything that was said about the conventional jet aircraft could be said about the supersonic transport, only more so. The extremely thin wings required for flight faster than sound, with their extremely sharp lead edges and radical platforms, make the achievable lift coefficients very low and the probable approach drag coefficients very high. I feel quite sure that a very sophisticated BLC system will be at the heart of the concept of a practical aircraft of this type.

VTOL aircraft

There is, of course, the ultimate in short runways, the VTOL aircraft. And here we find many, rather than too few configurations that are accepted. As I am looking at this problem from the viewpoint of one who is engaged in mass transportation, you will forgive me if I lack enthusiasm for a vehicle merely because it can hover, or even land or take-off short. It must also be a useful vehicle — not only in an absolute sense, but also competitively to other alternative vehicles. The present-day crop of VTOL, including the helicopters, has one element in common — they are only useful under some limited circum-

4 Ways to Improve Jet Take-off & Landing

... continued

stances when the VTOL ability transcends all other requirements. However, the places in the world where nothing but a VTOL will serve the purposes are in the minority.

Now, quite obviously, we do not need to have VTOL aircraft in order to get airports somewhere within the city areas — rather than 30 miles out in the country. We must also realize that we can't have earth-shaking monsters, requiring three-mile runways for this sort of service either. Is there any benefit then from vertical rising capability within this framework?

It is becoming increasingly apparent that the major limits to high-speed operation between cities of moderate distances is the time the aircraft spends on the ground, nonproductively, taxiing, awaiting take-off, awaiting gates, and so forth. These unproductive minutes are becoming an increasing economic burden to the aircraft operator and, therefore, to the general public. The time is caused by two factors: the necessity for taxiing long distances, which increases as the runway length increases, and the interferences that many aircraft on the ground create for each other by clogging taxiways, blocking take-off positions, and generally interfering with each other. By and large VTOL aircraft, at least such VTOL aircraft as can take-off from their landing positions, will eliminate this time involved.

That this time is worth salvaging may be more apparent if you realize that in October 1958, certain flights of my company averaged 25 min on the ground . . . taxiing, awaiting clearances, running up, and awaiting gates. This degree of confusion appears to be getting rapidly worse as the number of aircraft movements on a given airport increases. It is quite obvious that, even at best, traffic control on the ground can only hold this congestion to perhaps present levels. A VTOL aircraft can eliminate some 15 min average ground time from the present operation when operated from present-day airports. It obviously can eliminate the need for extremely long airports so burdensome to communities. If such a machine can be built so as to decrease the net travel time between cities and at the same time be entirely competitive or economically superior to the present style of aircraft, it will be widely accepted.

One configuration that has tremendous promise in this respect is the so-called, "hover" jet aircraft configuration, which derives its lift for take-off and landing from a multitude of vertically positioned jet engines but which cruises as a conventional aircraft with very much reduced wing and cruise powerplant dimensions. This kind of machine appears eventually to be competitive for even fairly respectable ranges, depending upon the achievement of extremely low weight to thrust ratios and extremely small volume to thrust ratios for the lifting powerplants. Certain of our engine companies have made a start towards producing such a powerplant. While they are not quite to the point of economical feasibility, they are progressing enough so that we can afford to entertain this possibility.

To Order Paper No. 60T ...
... on which this article is based, turn to page 6.

New A-C for Trucks

Based on paper by **W. C. Edmundson**

Delco-Remy Division, General Motors Corp.

WHILE the d-c generator has been vastly improved, a new self-rectifying a-c generator has been developed which charges at idle, gives 60% more output per lb, and is more durable.

This durability has been made possible by substitution of silicon rectifiers for selenium ones (Fig. 1). The silicon rectifiers are smaller, less fragile, and less subject to damage because they are mounted within the generator, which also conserves space and minimizes outside connections. Furthermore, each part can be replaced individually.

Pole construction was selected for this generator to meet the design requirement of low cost in high production. A voltage regulator with the usual vibrating points, but incorporating a transistor, was designed to handle 50 amp of field current, without which the high output in a generator of this size would have been impossible. Part of the field current is diverted through the transistor base and the points so that the total field current is controlled by the fraction of an ampere passing through the points.

A full transistor regulator, which eliminates all moving parts, is also available. A zener diode is used as the voltage sensing device. It starts to pass current at the same potential each time the voltage rises to this potential, shutting off the field current through the transistor circuits (Fig. 2) until the voltage falls below this potential. A field discharge diode is used to short-circuit the inductive energy of the field when the circuit is interrupted. The voltage is set by potentiometer adjustment at the factory and can be adjusted externally up or down in two 0.3-v steps by changing the connections in the voltage divider.

Meeting New Current Demand

City coaches have been putting an ever increasing load on generators, what with special lighting, heat-

Generators and Buses

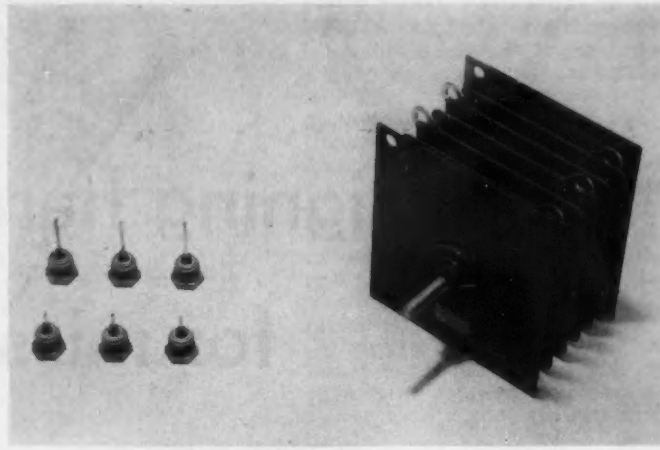


Fig. 1 — Silicon rectifiers (left) are smaller and less fragile than selenium rectifiers (right) and give a-c generators great durability.

ing, and air conditioning. Most of the capacity is needed at idle because the average speed in many metropolitan areas is only 5 mph and driving is of the "goose and coast" variety. To meet increased requirements, the first really large generator had a 55-amp output in a 12-v system. From this the step was made to a 120-amp rating without increasing generator size. To maintain adequate low-speed performance, the field coil strength had to be increased by a "split field" construction. But when loads went beyond 90 amp, the construction became inadequate, and brush life and cooling became a problem. So a new and radical design of generator was conceived.

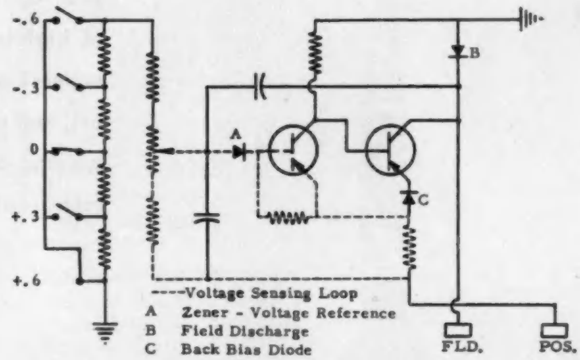


Fig. 2 — Circuit of full transistor voltage regulator. A zener diode is used as the voltage sensing device.

High Output, Long Life

This new generator, having a top output of 215 amp and 135 amp at idle, weighs about the same as its split-field predecessor — 130 lb. Cooling is accomplished by circulating engine oil inside the case. This banned the use of conventional carbon brushes on commutators, or slip rings, so a brushless design was adopted. The high-output rectifiers are cooled by the same oil used to cool the windings, by mounting silicon rectifiers under a cover opposite the drive end. The silicon diodes are much smaller than the selenium plate rectifiers and are sealed against contamination and damage (Fig. 3).

The problem of finding insulating materials and varnishes which would stand up in hot oil has been solved and the quality indicates that the whole generator should last as long as the one-hoss shay. The absence of slip rings and brushes, the high-grade materials, and the elimination of all wearing parts other than ball bearings, which are copiously supplied with clean oil, should make the unit indifferent to load or environment.

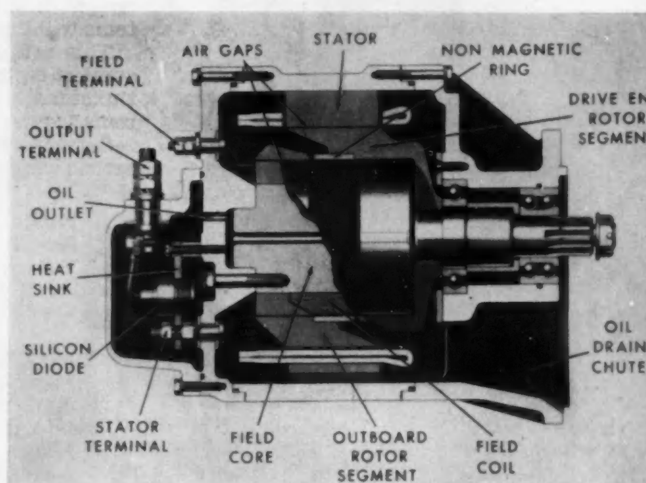


Fig. 3 — Cross-section of brushless a-c generator. High-output silicon rectifiers are mounted under a cover at opposite end from drive and are cooled by engine oil circulating inside the case. The magnetic path is from one pole to the rotor fingers through the stator to the outboard fingers (supported by a nonferrous ring from the rotor on the shaft) to the other pole and back through the core.

To Order Paper No. 81T . . .
. . . on which this article is based, turn to page 6.

Designing hard installations for missiles isn't easy

● **The design of ground support systems for hard installations is a sophisticated engineering task, requiring the application of high-level mathematical techniques. This area of ground support equipment is a definite extension of the state-of-the-art, and one that will continue to require a high level of engineering competence on the part of the ground support equipment contractor.**

Based on report by secretary **Theodore D. Dritz**
Burns and Roe, Inc.

HARDNESS ENGINEERING deals with the design of equipment and facilities to withstand the effects of a nuclear or thermonuclear explosion. Today, Titan and Minuteman are committed to "hard" installations — tomorrow, many other fixed missiles systems will undoubtedly be hard.

This article discusses some of the problems facing the ground support equipment designer in the design of hard installations for the storage, maintenance, and launching of selected missile systems.

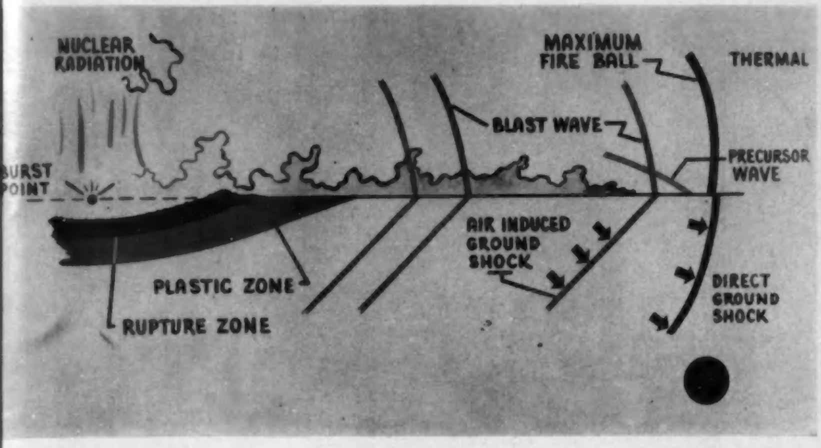
Serving on the panel which developed the information in this article were:

Panel Leader:
Ross B. Hooker, The Martin Co.

Panel Secretary:
Theodore D. Dritz, Burns and Roe, Inc.

Panel Members:
Joseph D. Hadad, Raytheon Manufacturing Co.
Warren R. Stumpe, American Machine and Foundry Co.
William A. Matthews, Sperry Gyroscope Co.
Joseph W. Albright, Chrysler Corp.
Warren F. Opitz, The Martin Co.

(This article is based on a secretary's report of a production panel entitled "Ground Support Equipment." This report — along with 6 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-327. See order blank on p. 6.)



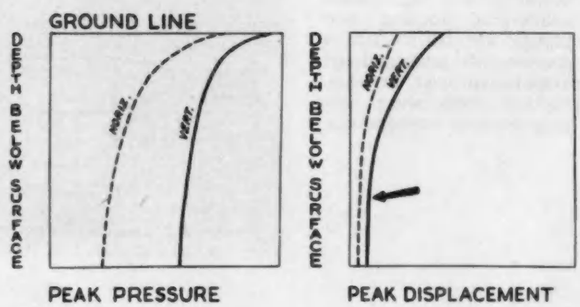
FOUR BASIC PARAMETERS DEFINE a particular nuclear environment and dictate the design of a hard system to protect against it. These are: 1. air blast; 2. ground shock; 3. nuclear radiation; 4. thermal radiation. The diagram identifies these parameters, indicating the burst point with the rupture and plastic zone, blast wave, precursor wave, air-induced ground shock, direct ground shock, nuclear radiation, and thermal radiation within the maximum fire ball.

Complete analysis of each parameter provides useful data for the ground support equipment engineer on which to base equipment design.

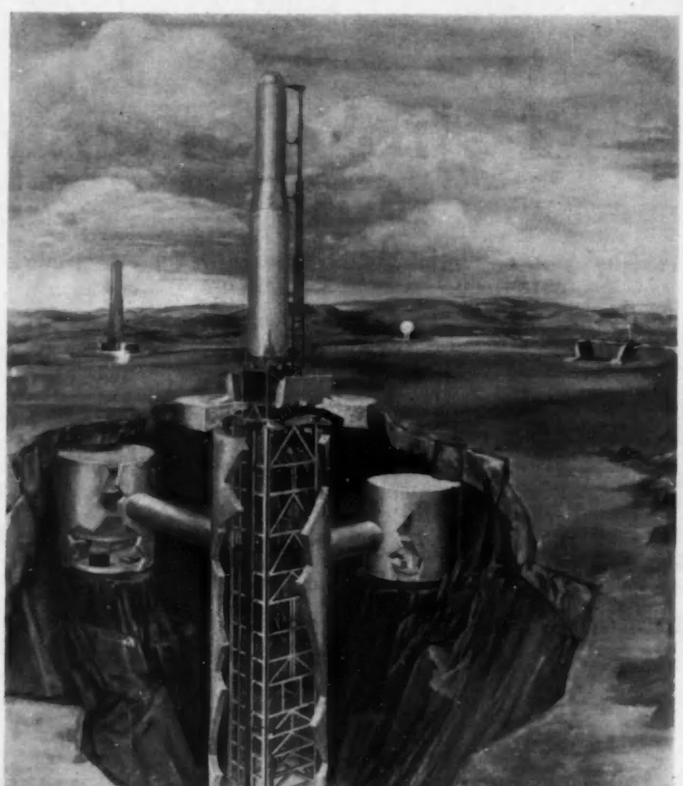
COMPLICATING THE DESIGN OF A HARD SYSTEM is the fact that the parameters vary with the megaton yield of the bomb, the desired overpressure, and the soil conditions. When these variables are specified, useful design curves (as shown at right) can be generated for ground shock.

Ground shock occurs in the form of systematic and random shock. Systematic shock is the gross shock motion resulting from direct action of the air blast while random shock includes effects from directly transmitted ground waves. Soil condition is, therefore, an important variable in assessing the total ground shock effect.

The illustration gives typical design curves for pressure and displacement varying with surface depth. Note that the displacement curve reaches a constant value at some depth indicating that there is a limit to protection offered by depth below the surface.

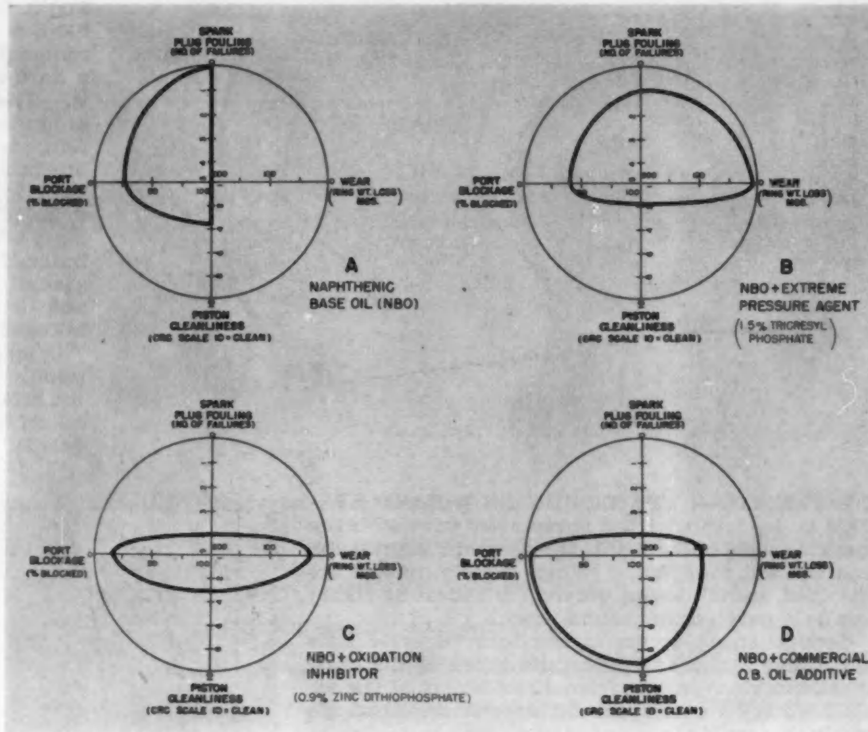


Similarly for the other three parameters of air blast, nuclear radiation, and thermal radiation, design data can be generated to guide the ground support equipment designer in his equipment requirements.



THE TITAN ICBM LAUNCHER SYSTEM achieves "hardness" through three underground silos. The central silo houses the missile, the two outer silos equipment and propellants.

The underground installation gives protection against air blast since it is flush with the ground. To isolate against ground shock, a shock mount system is required for all equipment, structures, utilities, and such, and, of course, for the missile. Protection from both nuclear and thermal radiation is achieved by the design of an adequate closure with the required mass to attenuate these factors to tolerable levels.



(A) Naphthenic base oils without additives have poor wear and piston cleanliness characteristics, but are good as regards port deposits and spark-plug fouling. (B) Adding an extreme-pressure agent (1.5% tricresylphosphate) reduces wear sharply but makes other characteristics worse. (C) Use of an oxidation inhibitor (0.9% zinc dithiophosphate) reduces wear and port blockage but increases spark-plug fouling and piston varnish. (D) A commercial outboard oil additive proved unsatisfactory from wear and plug fouling standpoints.

Designing oils for a 2-stroke engine

Based on paper by

J. W. Savin,

Atlantic Refining Co.

ADDITIVES can have good or evil effects in oils for 2-stroke engines, but a properly compounded oil will give a performance far superior to the best non-additive oil.

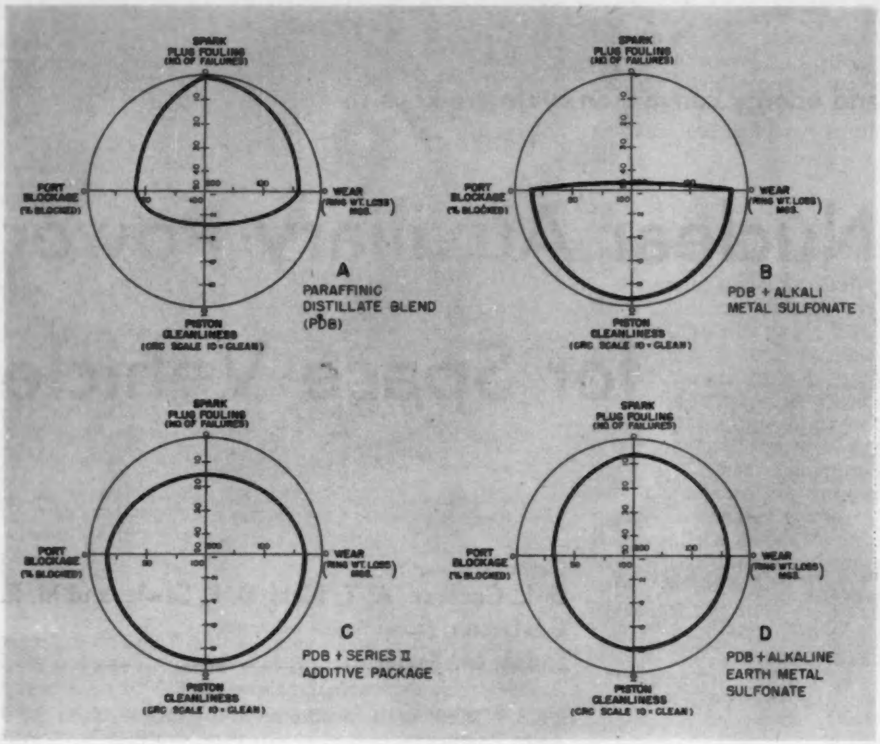
There are four fundamental requirements of a lubricating oil. These are:

1. Provide good lubrication — minimize ring and cylinder wear, protect against piston seizure, and adequately lubricate bearings.
2. Cause minimum spark-plug fouling.
3. Burn with minimum deposition in combustion chamber and exhaust ports.
4. Give minimum piston varnish deposits or eliminate them.

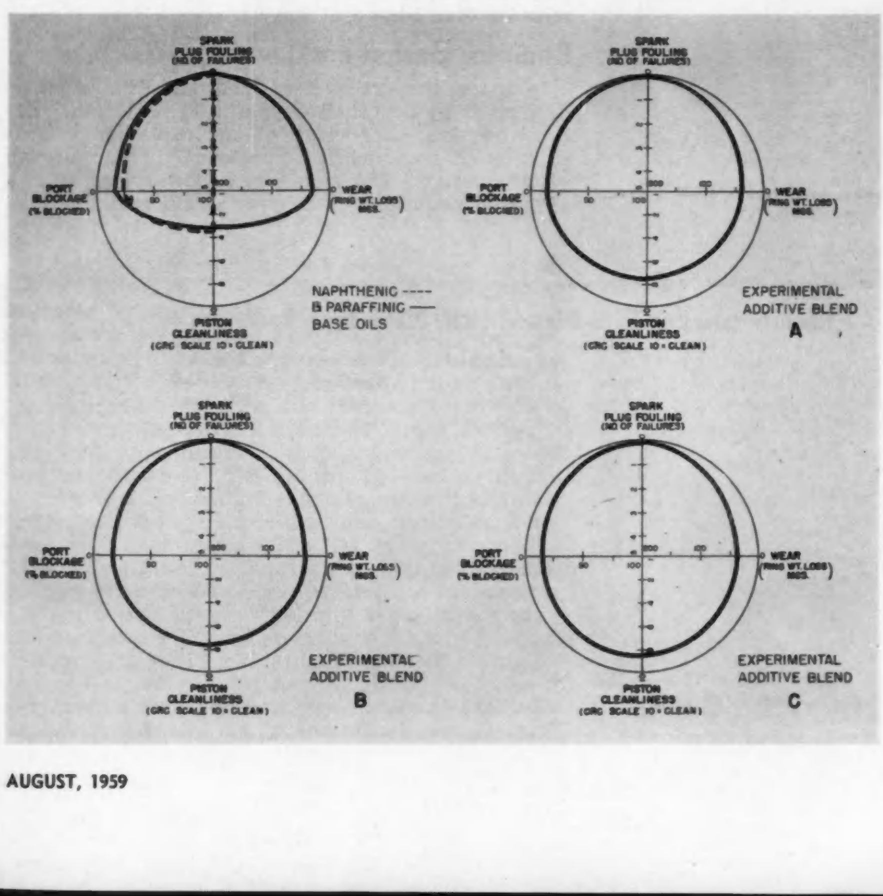
Lab Test of Oils

Laboratory tests of additive oils have been made with a 2-stroke, aircooled, motor-generator set, using a cycling procedure with periods of full-, half-, and no-load operation coupled with a shut-down or cooling period. The basic operation called for an 8-hr cycle, which could be repeated as often as desired. The results, which correlate well with field results, in a 48-hr test time are shown in the accompanying polar charts. All scales, including the CRC varnish scale, are constructed to represent best performance at the circumference of the circle.

To Order Paper No. 65T . . .
. . . on which this article is based, turn to page 6.



(A) Paraffinic base oils without additives have the shortcomings of high port deposits and piston lacquering. (B) Adding an alkali metal sulfonate greatly improves piston cleanliness, but at the expense of heavy spark-plug fouling. (C) A Series II additive package again shows great improvement in piston cleanliness and with less penalty in the way of spark-plug fouling. (D) Adding an alkaline earth metal sulfonate improves the base oil in port blockage and piston cleanliness characteristics.



Comparison of overall performance of three completely different oil compositions and classic outboard naphthenic and paraffinic base oils shows the extent to which the ideal oil can be approached by careful selection of the base oil and the additive components.

Radiators, materials, and energy conversion cycle are keys to

Nuclear Auxiliary Power for Space Vehicle

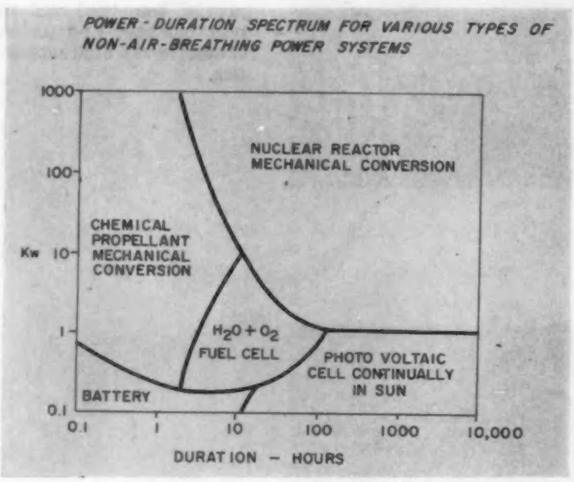


Fig. 1 — Time and power level determine proper type of auxiliary power unit to be applied to space vehicles or satellites.

Exerpts from paper by

D. L. Cochran, A. T. Biehl, D. R. Sawle, and M. R. Gustavson Aerojet-General Nucleonics

and A. M. Taylor

Turbo-Machinery Division, Aerojet-General Corp.

THE THREE main problems of a space nuclear APU are its radiator, energy conversion cycle, and materials. Solutions to these problems will make nuclear auxiliary power units a logical choice for high-power, long duration-applications where air-breathing powerplants can't be used. Fig. 1 positions the role of nuclear power with respect to other non-air-breathing systems.

Radiator design and location

In space, the excess heat from the APU must be dissipated by Stefan-Boltzmann T_4 radiation. Because of this, the design of the radiator, or heat sink, is of paramount importance in the overall system design. For example, a powerplant with a 10% thermodynamic efficiency and a radiator tem-

Table 1 — Characteristics of Two-Dimensional, Plate-Type Radiators

Shape[a]	No. of Elements	Angle between Elements, deg	Shape Factor, S_f	Actual Area/Unit Axial Length	Effective Area/Unit Axial Length	Relative Weight/Unit Effective Area
A ○	-	-	0.500	$4\pi r$	$2.0\pi r$	1.000
B —	2	180	1.00	4 r	4.0 r	0.500
C ⅄	3	120	0.866	6 r	5.2 r	0.577
D +	4	90	0.707	8 r	5 66 r	0 705
E ✶	5	72	0.588	10 r	5.88 r	0.850
F ✳	6	60	0.50	12 r	6.0 r	1.00

[a] All shapes circumscribed by a circle of radius *r*.

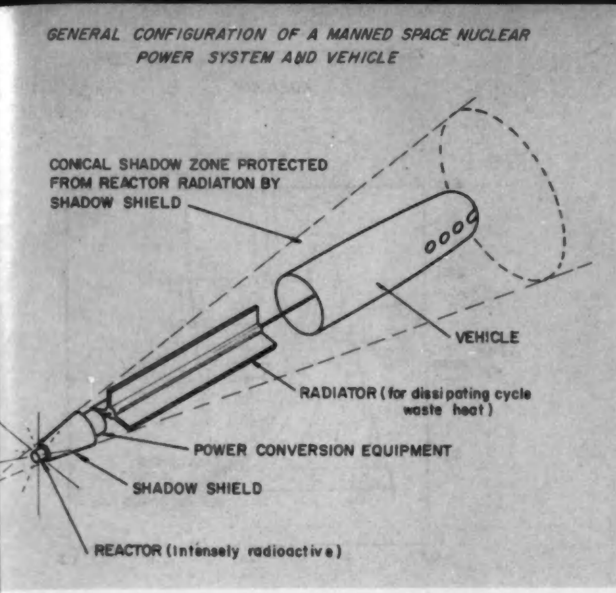


Fig. 2 — Auxiliary power system can lie between reactor shield and vehicle. All parts should be in shadow cone if secondary scatter is to be avoided.

perature of 500 F will require 21 sq ft of surface for each kilowatt of power. If the radiator temperature is raised to 1000 F, only 4 sq ft are necessary. High radiator temperatures are a must even though materials problems will be accelerated.

The radiation area quoted in the example was for a flat plate where all of the surface "sees" open space. Such a surface isn't feasible from a structural standpoint, so radiator area is further increased by a shape factor. Table 1 gives the efficiencies of various types of plate-type radiators. From the table, it appears that a three-element configuration offers a good shape factor and structural rigidity.

Micro-meteorite damage is another important radiator design factor. The lighter the wall thickness, the greater the probability of penetration. The balance will be between weight and reliability. However, if radiator weight is doubled, the meteorite damage is cut by a factor much greater than one-half.

In locating the radiator, the requirement that all system components be confined within the shadow projected by the reactor shield must be met. If components protrude beyond this shadow, they can scatter enough radiation back to the vehicle to be harmful to the crew. Fig. 2 shows one logical solution achieved by putting the radiator between the reactor and the vehicle. Reactor shield weight is thus kept to a minimum and all components are shielded. There are distinct problems with this arrangement if the vehicle has to re-enter the atmosphere, both from a structural and radiation viewpoint.

The very nature of the nuclear APU presupposes that it will be called on to operate in a vacuum for long periods of time. Making a high-temperature structure that will have no leaks to the surrounding vacuum is, in itself, a formidable problem. Experience at Oak Ridge indicates that it can be done if every design detail is carefully chosen to facilitate vacuum tightness. For temperatures above 400 F, the system should be completely welded, and wall thickness not less than 0.030 used. No castings should be used and all of the containing envelopes should be of wrought materials with the direction of working parallel to the surface. This problem of system leakage also applies to other parts of the APU.

Selecting the thermodynamic cycle

A simple two-loop Rankine vapor-cycle will probably give low overall system weight and volume, good reliability, long life, and the reasonably short development time needed for the space APU.

The vapor cycle is attractive from the thermodynamic viewpoint because most of the heat is added at a single high temperature and removed at a single low temperature. This is accomplished with a fluid in two-phase equilibrium. The fluid can be heated at constant pressure in a region under the vapor dome of the *T-S* diagram, where temperature depends only on pressure. Moreover, in a vapor cycle, the vapor can be expanded to extract work while liquid compression, which requires relatively little work, can be used to complete the cycle. For this reason, relatively inefficient pumps can be used without appreciable loss in cycle efficiency.

A difficulty that may be encountered in the operation of a Rankine cycle is moisture condensation in the vapor stage damaging turbine blades. How-

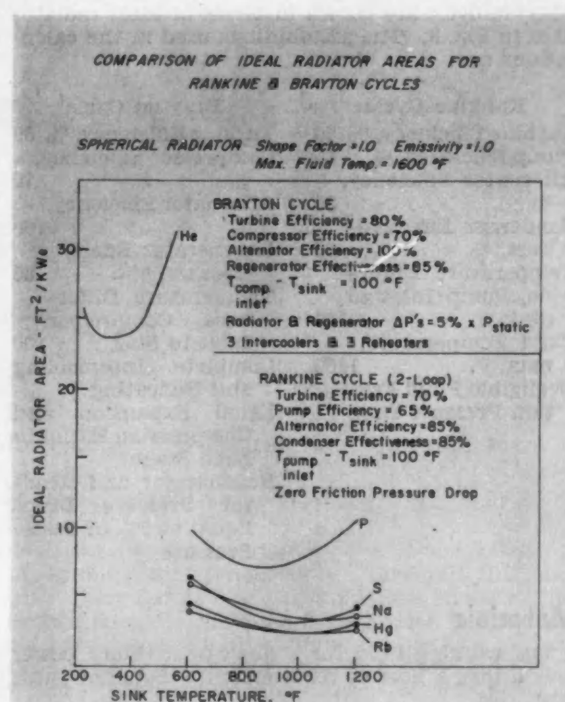


Fig. 3 — Rankine cycle shows a distinct advantage over Brayton gas cycle when radiator weights are compared. This particular parameter is used because the radiator is one of the most critical factors in the design of the powerplant.

ever, at low power levels, a single-stage turbine will be used, and the transit time through the turbine will be so short that moisture formation will be minimized. The problem of turbine moisture can be resolved by modifications of the simple Rankine cycle using superheaters or extractors. Generally, such modifications result in reduced cycle efficiencies because of reduced boiler (reactor) temperature and increased complexity.

On the other hand, a gas cycle at first seems to have many advantages. These include the use of inert gases such as helium or nitrogen. With these gases, there would be essentially no radiation problem from neutron bombardment, corrosion problems are simplified, and there is no zero-gravity condensation problem. Unfortunately, the radiator areas required for gas cycles make them unattractive for the power levels and source temperatures of present interest. Also, for example, in the simple Brayton gas cycle, a large part of the heat is added at low temperatures, tending to give low cycle efficiency. This can be partially compensated for by regeneration, but regeneration is possible only if the turbine outlet temperature exceeds the compressor outlet temperature. At low pressure ratios this may not be the case.

At higher pressure ratios, the irreversibilities in the turbine compressor tend to offset the gain due to regeneration, and there is a pressure ratio above which no net work results. There is also a low limit to the pressure ratio below which a nonregenerative Brayton cycle will not produce work.

For comparison, a simple two-loop Rankine vapor-cycle and a regenerative-intercooling-reheat Brayton cycle are shown in terms of ideal radiator area in Fig. 3. The assumptions used in the calculations are:

Rankine Cycle	
Turbine Efficiency, %	70
Pump Efficiency, %	65
Alternator Efficiency, %	85
Condenser Effectiveness, %	85
Temperature Difference, Pump Inlet to Sink, F	100
Fluid Temperature, max, F.	1600
Negligible Fluid Friction Pressure Drop	

Brayton Cycle	
Turbine Efficiency, %	80
Compressor Efficiency, %	70
Alternator Efficiency, %	100
Regenerator Effectiveness, %	85
Temperature Difference, Compressor Inlet to Sink F	100
Complete Intercooling and Reheating	
Equal Expansion and Compression Ratios in Each Stage	
Regenerator and Reactor Pressure Drops Equal to 5% of Static Pressure	

Materials

The working fluid for a nuclear auxiliary power unit brings a host of requirements. Some of these are:

- **Neutronics** — low neutron absorption and unaffected by neutron bombardment.
- **Thermodynamics** — satisfactory interrelationship between pressure, volume, temperature, entropy, and other parameters as well as desirable phase characteristics.
- **Heat transfer** — high transfer rates with low fluid friction loss.
- **Corrosion** — compatibility with reactor, turbine, pump, radiator, and other system components.
- **Stability** — high temperature, time, and radiation.
- **Startup** — if fluid is solid under normal environment, then liquefying procedures are necessary to bring system into operation.

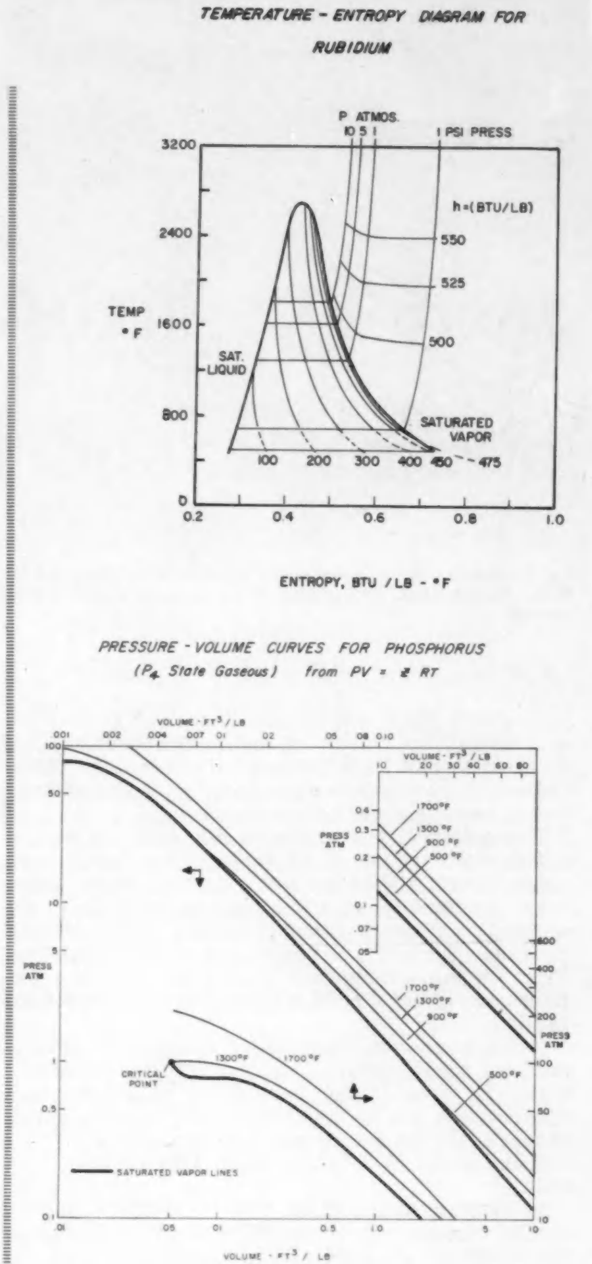
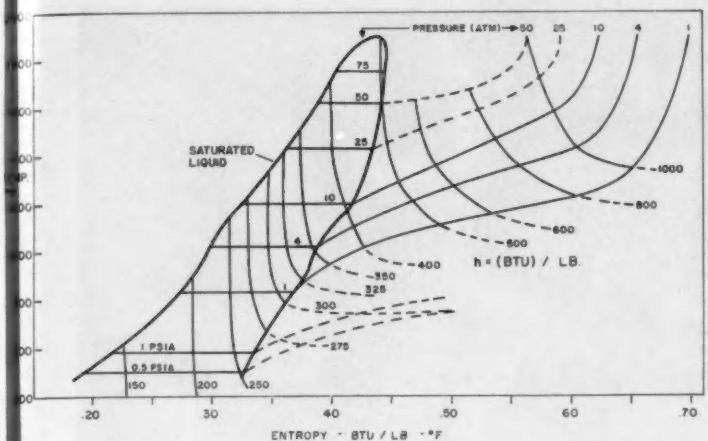


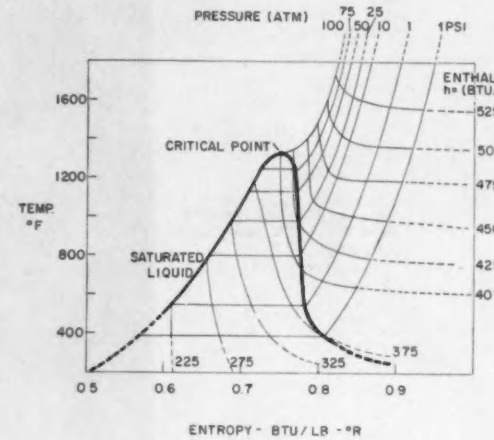
Fig. 4 — Rubidium, sulfur, and phosphorus are

little data available on their high-temperature

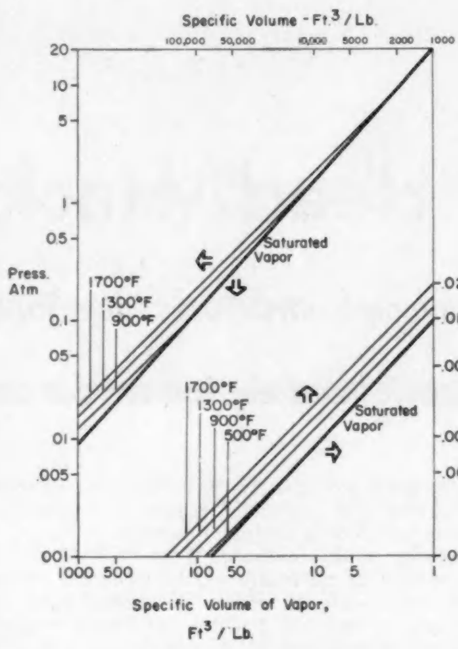
TEMPERATURE-ENTROPY DIAGRAM FOR SULFUR (S_8 IN LIQUID - S_2, S_6, S_8 IN VAPOR) (Chemical Equilibrium State)



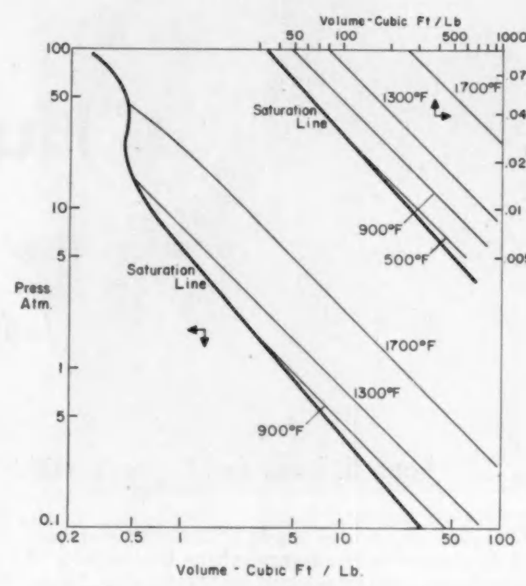
TEMPERATURE-ENTROPY DIAGRAM FOR PHOSPHORUS (α WHITE LIQUID - P_4 GASEOUS)



PRESSURE-VOLUME CURVES FOR RUBIDIUM VAPOR



PRESSURE-VOLUME CURVES FOR GASEOUS SULFUR (S_2, S_6, S_8 Mixture)



three possible fluids which could be used to transfer energy from the reactor. However, there is

characteristics. Above data represent a synthesis of the information now available.

• **State of Knowledge** — data must be available on fluid characteristics or a data development program must be feasible.

• **Cost** — expense of producing and availability.

Some possible fluids are helium, nitrogen, sulfur, phosphorus, rubidium, and sodium. There is a reasonable amount of data on all these materials except sulfur, phosphorus, and rubidium. Fig. 4 give *T-S* and *P-V-T* diagrams for these three materials. These data have been synthesized from somewhat meager available information and are useful for preliminary calculations only. However, the general characteristics of the fluids are shown. The critical point for rubidium is very much in question. Mercury, sodium, and rubidium behave in a normal fashion, but sulfur and phosphorus are quite different. The peculiar dome shape of sulfur comes from the various species (S_2, S_6, S_8) that exist at different temperatures. Phosphorus similarly undergoes a phase change.

To Order Paper No. 53T . . .
. . . on which this article is based, turn to page 6.

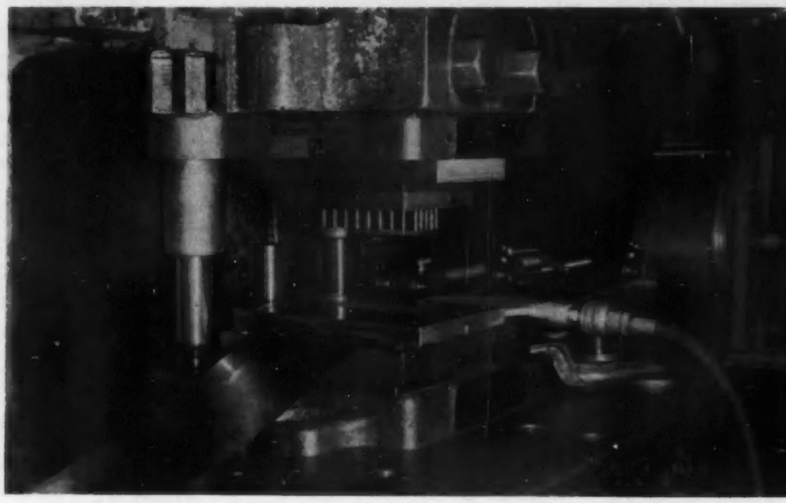


Fig. 1 — Blanking breather holes in 17-7PH honeycomb core strip.

"Hula Head" Hacks

Stainless steel honeycomb structures developed led to specialized equipment for core

Based on paper by

Leon E. Laux and Clyde S. Hill

The Martin Co.

HONEYCOMB structures made entirely of stainless steel to overcome the temperature limitations of aluminum have been developed by Martin Co. To do this, they had to solve not only the problem of assembling the panels but also of obtaining the basic core itself.

This resulted in the design and manufacture of unique techniques and equipment — such as a semiautomatic resistance welding machine, "hula head" machining of compound contoured sections, both hot and cold contour forming methods, and a tool for Z section edge member forming.

Considerable research is also going into methods for assembly of steel honeycomb sandwich structures. The electric blanket brazing technique is one Martin development.

Fabricating honeycomb core

A survey showed that for operation temperatures up to 800 F, the precipitation hardening alloys 17-7PH, PH15-7Mo, AM350, AM355, and the martensitic alloy 422 were suitable for honeycomb sandwich construction. For the 1200 F range, alloys similar to A286, Haynes 25, and Inconel are good.

To develop honeycomb core from 17-7PH, the core strip — which is normally 0.0015–0.003 in. thick — was first slit to a 4-in. width. Breather holes were then made in the foil by the automatic roll reed blank die shown in Fig. 1. The strips were then cut to approximate length, and shaped on a special design form roll machine (Fig. 2). Many cell configurations have been developed — such as square, corrugated square, multiwave, and 90-deg flanged square cells. Of these, the square cell configuration has proven best for general use.

To seamweld the formed foil into honeycomb core billets, Martin designed and manufactured the first semiautomatic resistance welding machine. This equipment (Fig. 3) is capable of producing honeycomb billets of ¼-in. square cell size, 4 in. thick, in sizes up to 36 in. wide by 10 ft long.

Machining honeycomb core

Welded steel honeycomb billets are machined to precise tolerances (± 0.002 in.) in preparation for their assembly into sandwich structures.

Fig. 2 — Form rolling 17-7PH honeycomb core strip.

Honeycomb

by Martin Co. have

processing and panel assembly.

Fig. 3 — Semi-automatic resistance welding machine seamwelds honeycomb core billet.

The initial sizing of flat core panels from the original core billets is done by friction sawing (Fig. 4) to a plus tolerance of 0.075–0.100 in. over the required final thickness. The sawed slab is then passed through a precision belt sander, which removes the excess material to the final ± 0.002 in. thickness tolerance.

To produce offsets in flat core panels, a setup was developed which incorporates a holding fixture; a base with two motors mounted 90 deg to each other; and two disc cutters so arranged that one disc cuts the depth of the offset while the other cuts the width.

Tapered core sections are made by first attaching the flat slab to an adjustable angular plate by cementing or freezing water in the cells. Following friction sawing, the final sizing is done with disc cutters (Fig. 5).

The most imposing challenge was the compound contouring of honeycomb core — since no standard equipment or proved machining technique was available. Fig. 6 shows a special portable head which was designed to convert any three-axis controlled equipment, such as the Hydrotel, into a five-axis system.

The pickup points on the stylus pass over a

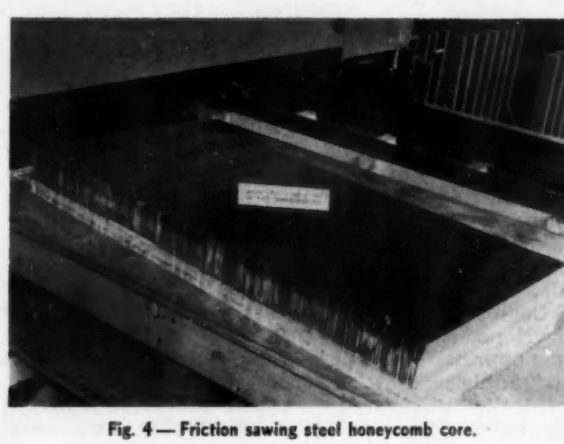


Fig. 4 — Friction sawing steel honeycomb core.

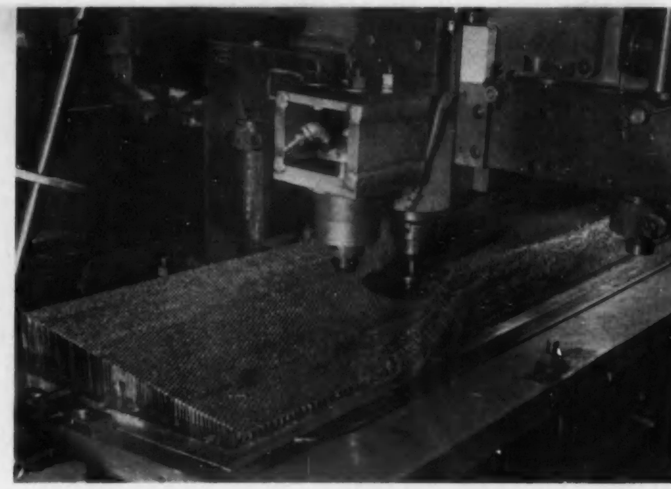


Fig. 5 — Disc cutting tapered core.

"Hula Head" Hacks Honeycomb

. . . continued

wooden or plaster model of the part, determine the angularity of the knife edge cutter, and guide it through a path that is a duplicate of the one generated by the model. The head is capable of tilting plus or minus 10 deg in two perpendicular directions; and there is a common focal point on the centerline and end of the cutter. The tracer controls are a combination of pneumatic, hydraulic, and electronic components. The power for driving the disc cutter comes from a 12,000 rpm air motor.

This unit — popularly referred to as the "hula head" — has proved very effective in accurately producing both male and female compound contoured honeycomb core sections.

Forming honeycomb core

Two techniques for forming steel honeycomb core have been developed. The first — applicable to single contour configuration — utilizes a formed stainless-steel female die into which the flat machined core slab is laid. Loose steel bars are placed on the surface of the core, and the tool and core are then heated to 1400 F in a controlled atmosphere furnace. At this temperature, yielding of the core takes place and the pressure exerted by the steel bars forces the core to the exact shape of the female die.

Compound contour forming is done by a recently developed cold forming technique. Honeycomb core has opposite curvatures at a given point and tends to "saddleback" when bent in one direction. . . . But controlled compound curvature has been produced by reducing the cell size and modifying the pattern on the concave face of the core slab. Thus the neutral axis of the core is on the convex surface and no stretching occurs to cause fracture of the cell walls.

Edge member forming

Another development of the past year is a means of forming Z section edge members for honeycomb panels to tolerances of ± 0.003. The first bend in the section is accomplished on a power brake in the conventional manner. The second bend is made using a precision brake die, which is adjustable, and will accommodate sections of 0.250–1.200 in. in varying thicknesses. In order to maintain consistency from part to part, strip stock that has been precision rolled to a controlled thickness of ± 0.0005 in. is used.

A special check gage had to be developed. It uses a dial indicator, which measures the tolerance of the part as it is fed through rollers incorporated in the checking device.

Assembling honeycomb structures

Experience with adhesive bonding has proved it reliable and economic for assembling honeycomb sandwich structures. This method is but an interim step in the transition to the ultimate in metal-to-metal joining — but will continue to be applied to future aircraft and missile construction.

Brazing assembly of steel honeycomb sandwich components is rapidly being developed and refined. Experience with the resistance electric blanket in adhesive bonding assembly led to its use for brazing assembly. The electric blanket brazing fixture is a self-contained unit, incorporating the heating elements, cooling system, and associated tooling required to hold and apply pressure to the structure components (Fig. 7). The upper and lower blankets are made of insulating fire brick, on an aluminum framework, with a network of steel water tubes interplaced through the bricks to provide controlled accelerated cooling. Flat nichrome heating ele-

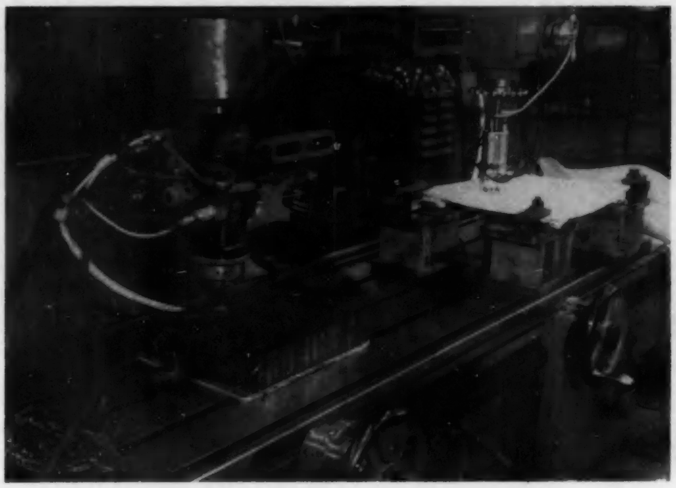


Fig. 6 — "Hula head" machines compound contour.

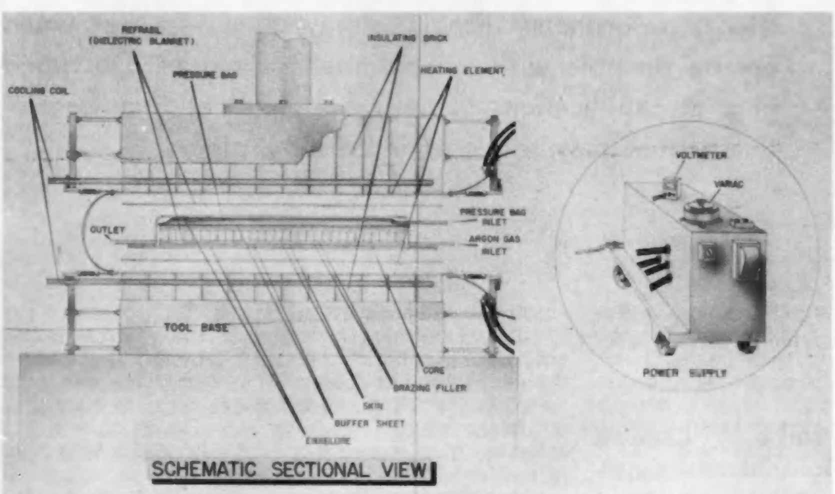


Fig. 7 — High-temperature electric blanket brazing.

ments cover the surface of each blanket. The temperature is regulated from a central control panel, through which the voltage is precisely controlled. Thermocouples give a constant reading of the temperature. Control is maintained within ± 25 F, in a range of 1725–2100 F for brazing, and ± 10 F in a range of 950–1050 F for subsequent aging.

After an assembly is laid up, it is placed in a stainless steel envelope. Tubes are inserted in the edges, and the complete envelope is seam welded to make an airtight container. The tubes through the edges of the envelope are used for evacuating the air and replacing it with argon gas. The latter provides an inert atmosphere — under a constant flow — during the brazing process to prevent oxidation of the panel. A flat stainless steel pressure bag provides pressure for insuring intimate contact of the panel components. It is located on or over the panel layup, inside of the argon purged atmosphere envelope.

Using the electric blanket brazing technique with the precipitation hardening alloys, the complete brazing and heat treating cycle was accomplished in 13½ hr, as opposed to 34 hr using conventional furnace brazing methods. Also, the electric blanket has little heat loss — operating at 65% efficiency, compared to the 10% brazing furnace efficiency.

To Order Paper No. 43S . . .
. . . on which this article is based, turn to page 6.

Radioisotopes

can do the otherwise-impossible, earthmoving engineers say

Radioisotopes are becoming increasingly important to industry and research, usually contributing accuracy, sensitivity, or economy. Problems may be solved that would not be possible with conventional techniques. Described here are applications in the tractor and earthmoving industry that may prove of interest to others

Abridgment of an
SAE Central Illinois Section paper

Excerpts from a paper by

W. P. Evans and E. W. Landen
Caterpillar Tractor Co.

RADIOISOTOPES have many metallurgical and mechanical applications of practical interest to the tractor and earthmoving industry. Some of these are described here as follows:

- Measurement of wear on sliding surfaces.
- Surface activation.
- Bleed rate of powered metal bushings.
- Gasket and seal evaluation.
- Radioactive position indicator.

Measurement of wear on sliding surfaces

As gear tooth wear is not uniform along the tooth profile, an overall measurement of the radioactive wear debris gives the total amount worn from a gear, but does not delineate the wear along the tooth profile. We wanted to evaluate wear in terms of the conditions prevailing at any point on the gear tooth. Since this could not be achieved on our particular gears, we used a pair of rollers to simulate the operating conditions of the gears. Fig. 1 shows the similarity between the action of the gear teeth and the mating rollers. At this particular position of the gear teeth the velocity V_1 of tooth A corresponds to velocity V_1 of the active roller, while the velocity V_2 of the mating tooth B corresponds to velocity V_2 of the non-active roller. Thus, gear tooth conditions are simulated by rollers.

The wear per unit area W can be represented functionally and separately for each tooth or for a roller by the formula:

$$W = f\,(V_1,\ V_2 - V_1,\ S_c)$$

where V_1 is active roller velocity, V_2 is non-active roller velocity, $V_2 - V_1$ is the relative sliding velocity of one member with respect to the other, and S_c is the calculated Hertz contact stress. The radius of the gear tooth varies along the active face of the tooth, but our present data have been obtained only from rollers having fixed radii. Roller diameters used in this test were 3.30 and 2.70 in. with the active face width of 0.180 in.; however, the overall width of the rollers was 0.500 in.

The roller test machine has two parallel shafts mounted on roller bearings. Each set of bearings is housed in a massive casting hinged so that a known load can be applied to the rollers. Each shaft can be driven individually, or the two shafts can be interconnected by phasing gears, providing

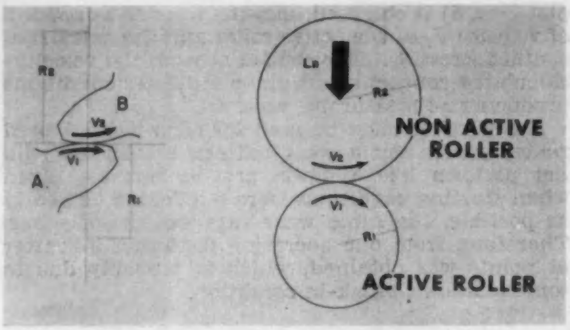


Fig. 1 — Comparison of gear action to roller action.

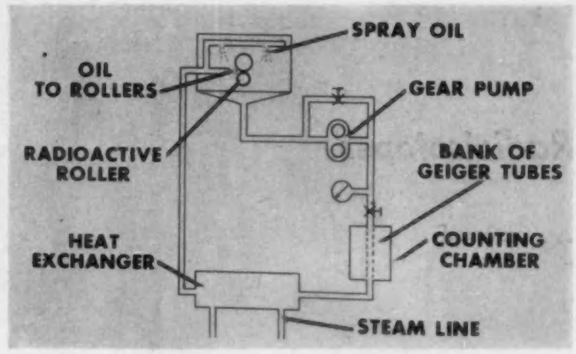


Fig. 2 — Schematic diagram of roller test setup.

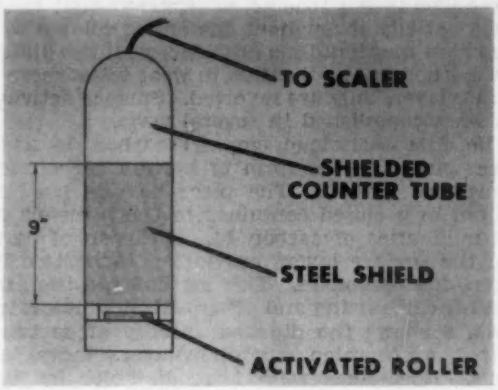


Fig. 3 — Method of measuring initial activity.

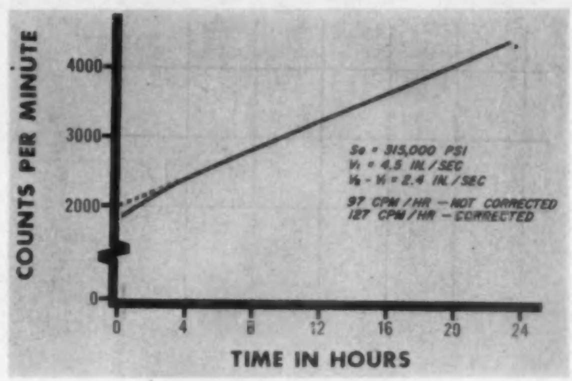


Fig. 4 — Typical raw data curve.

great versatility in controlling the operating conditions. A steel case surrounds the rotating parts so that the oil is confined in the system. The oil contains suspended radioactive iron, which must be kept in the system or in a storage container for disposal.

A ½-in. thick removable steel cover could be placed over the entire roller machine case, bringing the radiation down to a safe level. Extra steel blocks between hot roller and counting chamber reduce the background count. The roller test setup is shown schematically in Fig. 2. Sufficient oil is pumped through the setup to keep the wear debris in suspension. From the pump the oil is passed through a counting chamber containing water-cooled geiger tubes. The oil then flows through a heat exchanger to maintain a constant oil temperature and part of the oil flows to the rollers; the remainder flows into the housing of the roller test machine to keep the wear debris from settling out.

The counting chamber consists of eight side-window geiger tubes in parallel surrounding a pipe in the circulating oil system. The geiger tubes actuate a counter and a chart recorder so the count rate can be plotted as a function of time.

Calibration solutions of oil-soluble iron were prepared according to the Borsoff procedure. Decay corrections were applied from the time we received the rollers and the initial activity measurements were made.

Fig. 3 shows the setup for making initial activity measurements. It was found that the rollers were not of equal activity, even though they were activated at the same time. Our initial activity measurements were compared to one of our earliest rollers which we used as a standard. A correction factor was determined and applied to subsequent rollers.

Activity of a piece part placed in a nuclear reactor depends on a number of factors. For a steel roller of 200 g placed in a neutron flux density of 0.5×10^{12} for three weeks, an activity of approximately 20 millicuries of Fe 59 is produced. When one of these rollers is taken from the reactor it produces a gamma intensity of approximately 140 milliroentgens per hr at 1 ft. Rollers of this activity can be handled safely, during assembly, with tongs 3 ft. long.

Fig. 4 shows typical raw wear data in terms of activity in counts per minute as a function of time. Applying the calibration data, the decay correction, and the initial activity correction factor, the slope of this line gives the wear in terms of wear per cycle of the active roller, which can be interpreted in terms of wear per unit area. Each graph of this type gives a wear point depending on the conditions of the test. A number of these points for a given sliding velocity can be represented by an equation, $W = f(V_1, S_C)$ so that a three-dimensional

Radioisotopes

. . . continued

plot (Fig. 5) is obtained, showing wear as a function of velocity V_1 of the active roller and the calculated contact stress S_C. The shaded area on the velocity-calculated contact stress plane indicates conditions producing no measurable wear.

A new roller must be used for each run. A used roller, which had a wear pattern established, did not perform like a newly ground surface. Even when starting conditions were duplicated as nearly as possible, the same wear rate would not occur. Therefore, from one operating condition a scatter of points was obtained, which is probably due to some unknown break-in condition.

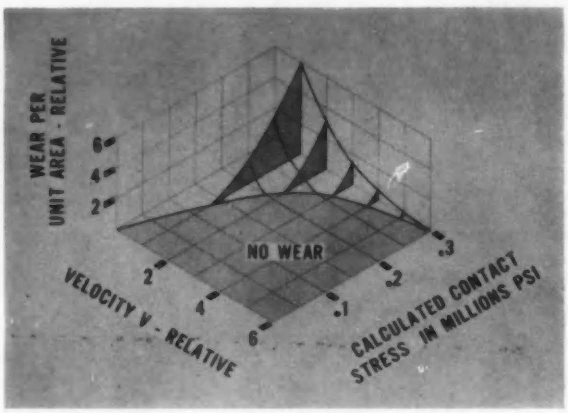


Fig. 5 — Three-dimensional plot of wear.

Surface activation

With this technique the outer surface layers only of a specimen or part are radio-activated. This is particularly true when the part is too large to be introduced into a reactor, or so heavy that the induced activity throughout the entire volume would be so high that handling problems would be difficult. The method has application in wear tests where the surface layers only are involved. Surface activation can be accomplished in several ways.

The first technique employs carbon 14 as the tracer either in the form of barium carbonate or amorphous carbon. The piece part is pack-carburized in a closed container in the presence of a few millicuries of carbon 14. Diffusion of carbon into the surface layers provides a carburized case containing carbon 14. This method has been used to study carburizing and other diffusion processes.

Fig. 6 shows the diffused activity of carbon 14 plotted as a function of depth by layer removal technique. Specimens were 1-in. diameter by ⅜-in. thick steel discs. The layers were removed by grinding the flat faces, and surface activity was measured with a thin mica end-window geiger tube. The accompanying autoradiograph of a section of a similar specimen shows visual evidence of penetration of the isotope. The autoradiograph was made by placing a polished section of the specimen in contact with Eastman Kodak Type NTB-2 emulsion coated on glass plates. This method gives activated surface layers 0.010–0.050 in. deep.

The second technique involves soaking a metallic part in a radioactive solution. Jaoul found that phosphorus 32 in the form of phosphoric acid solution can diffuse into a metallic surface to depths of 10–50 microns, depending on time and temperature. We have succeeded in reaching depths of penetration of the tracer to 0.003–0.005 in. in 1–8 hr immersion at 180 F.

Induced activity of the surface depends upon the normality of the solution and the specific activity of the solution. A small amount of hydrochloric acid enhances the penetration, although some pitting then takes place. We have removed the pits by lapping and grinding and have found appreciable penetration of the tracer extending approximately an order of magnitude below the pitting depth.

Fig. 7 shows a plot of penetration versus depth as a function of solution normality. Disc-shaped specimens, ¾ in. in diameter by ⅜ in. thick, cut from SAE 1045 cold-rolled steel were used. Normality was adjusted by small additions of HCl. Successive layers were removed from the flat surface by grinding and lapping. Activity measure-

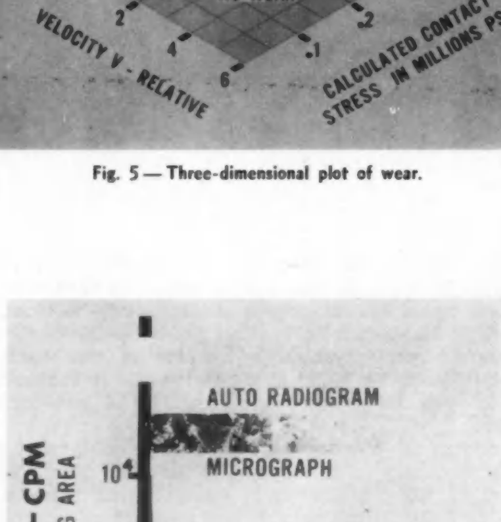


Fig. 6 — Penetration of carbon 14.

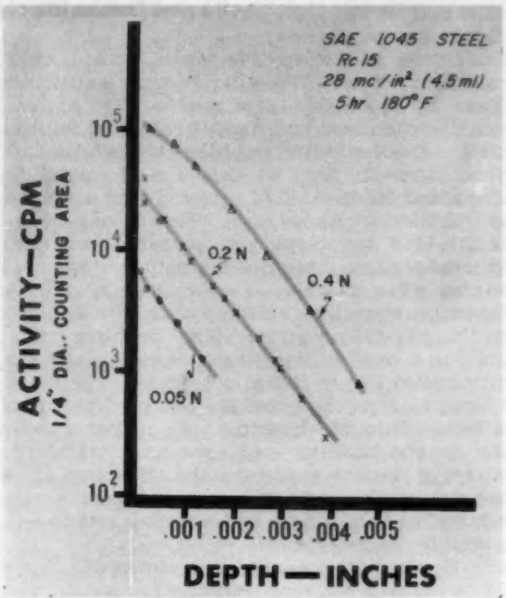


Fig. 7 — Penetration of phosphorus 32.

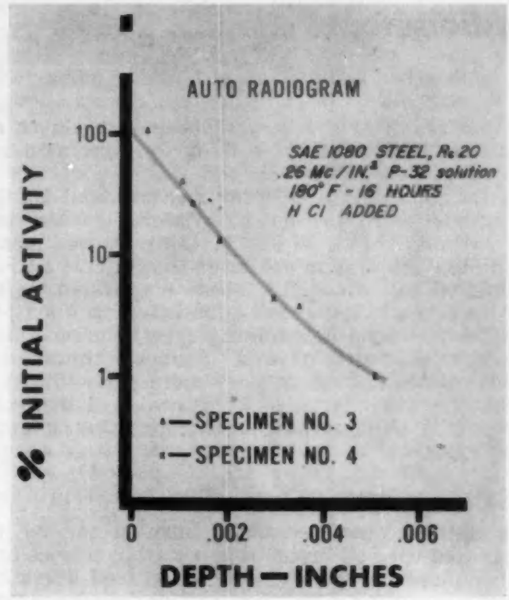


Fig. 8 — Calibration of wear test.

ment at discrete depths was determined with a thin mica end-window geiger tube. The end of the tube was covered with a brass diaphragm having a ¼-in. pinhole in the center.

For the acid concentrations shown, time of immersion was not a significant factor. Evidently, the reaction and penetration occurs quickly, probably during the first hour of immersion. Depth of pitting due to acid attack was approximately 0.0005 in. The acid also dissolved a thin layer uniformly from the sample, as indicated by determination of iron content of the solution after the soak. In the figure shown, depths refer to the original surface before the activation process was begun.

Part of the reaction results in the formation of a reddish-brown precipitate, which is highly radioactive and contains the bulk of the isotope used. Only a small percentage penetrates into the surface layers of the specimen. Assuming an exponential equation of penetration, the 0.4 *N* curve of Fig. 7 gives a mean of 0.01 millicurie of P 32 absorbed by the specimen of area 1.77 sq in.

When the bath reaches the precipitated stage, the solution is nearly of neutral pH. The P 32 is now in an unusable form and very little additional penetration can occur. The bath can be rejuvenated by redissolving the precipitate with HCl.

Phosphorus solutions were used in activation of the wear test specimens described in Fig. 8. An autoradiograph of a section is included for comparison with that obtained with C 14. In contrast to carbon 14, the concentration of P 32 varies markedly with depth, which makes wear measurement using this technique attractive. Recovery of wear debris is not necessary inasmuch as local measurement of activity can be made directly upon the specimen. The specimens were cylindrical in shape, approximately ⅜ in. in diameter by 2 in. long. The cali-

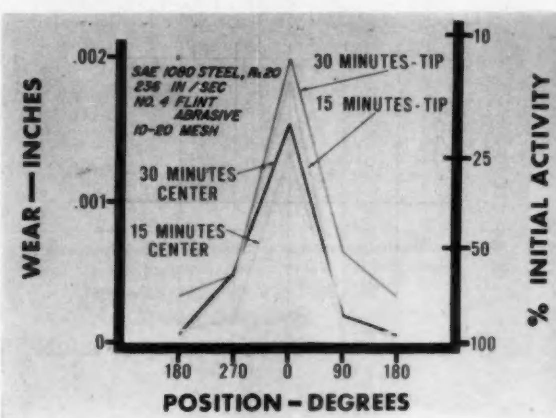


Fig. 9 — Abrasive wear.

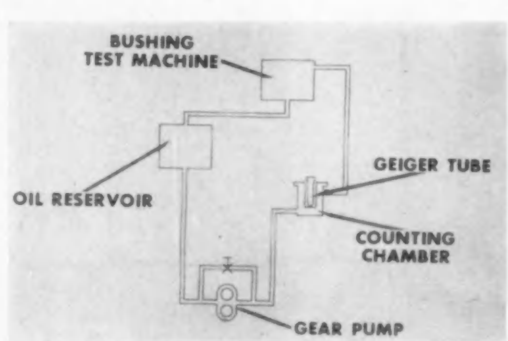


Fig. 10 — Schematic diagram of bushing test setup.

bration graph of Fig. 8 was obtained by layer removal technique of an end of the specimen not subject to wear in the wear test.

A feasibility study of wear measurement by this technique (as carried out in an abrasive wear test) gave results shown in Fig. 9. Activity was measured near the tip and center of the cylinder at four points 90 deg apart. A brass diaphragm covering an end-window geiger tube containing a ⅛-in. pinhole was used in scanning specific areas where measurements were desired. Such a technique appears particularly promising where it is difficult to catch the wear particles, or where local measurements may be of greater significance than average wear rates.

Bleed rate of powdered metal bushings

A sintered powdered metal bushing can be impregnated with oil before it is placed in service or it can be placed in service using an oil feed line without impregnation. This test was designed to measure the rate at which oil leaked from an impregnated bushing.

A solution of radioactive zinc (Zn 65) chloride served as a tracer. The zinc chloride solution neutralized by hydroxide produced a zinc hydroxide, which was dissolved in a naphthenic acid solution to form an oil-soluble zinc naphthenate solution. This concentrated solution of active zinc naphthenate when added to an SAE 30 oil produced a tagged oil that was used for these runs. Zinc 65 has a 250-day half life, and the strong gamma radiations emitted were used for actuating the counting system. It also produces weak gamma, as well as beta, radiations.

Bushings were impregnated with the active zinc naphthenate-oil solution. The bushing was immersed in a beaker of active oil solution and placed in a vacuum jar so the air could be expelled from the bushing. As the pressure returned to the oil it was forced into the bushing. An initial count was made on the bushing and used as a standard for comparing counts made on this bushing at later times during the test. In addition, these measurements showed the amount of oil going into the bushing during impregnation.

The bushing test machine consisted of a bushing retainer and a rotating shaft arranged so that a load could be applied to the bushing relative to the rotating shaft. The bushing was bathed externally with a flow of oil maintained at a pressure of 10–20 psi by a gear pump. Any radioactive oil leaking out of the bushing would then be washed into the circulating oil system. An electric motor powered the rotating shaft at the desired speed.

A schematic diagram of the oil system and geiger counter tube is shown in Fig. 10. Oil was pumped from the oil reservoir through the counting chamber to the bushing test machine. After the oil flowed past the sintered bushing, it returned to the reservoir. Oil tagged with the soluble radioactive zinc naphthenate would then become mixed with the remainder of the oil and would register as an increase in the count rate from the geiger counter. An increase in count rate indicated the amount of oil that leaked from the bushing as the test continued.

The entire oil circulating system was calibrated

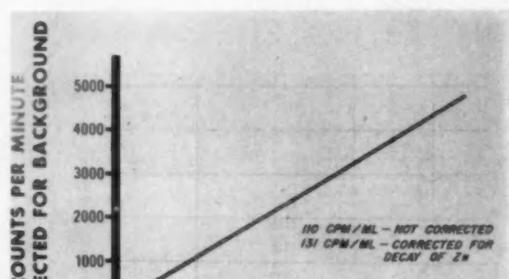


Fig. 11 — Calibration of Zn active oil in bushing test machine.

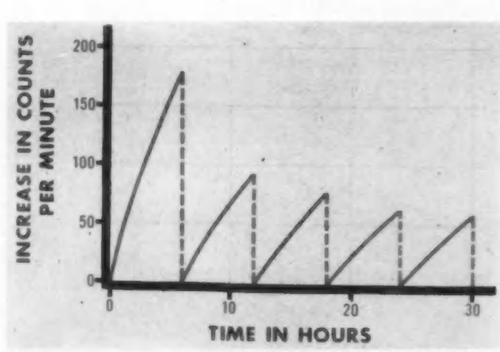


Fig. 12 — Counts per minute from active oil leaching out of bearing during 6-hr runs.

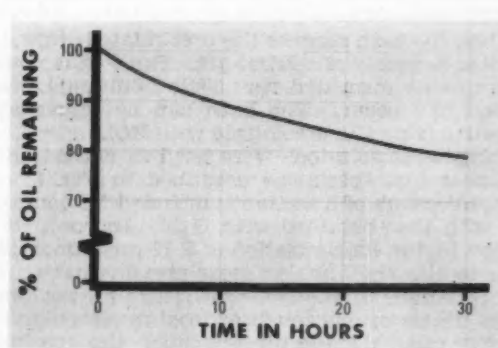


Fig. 13 — Oil remaining in bushing as function of operating time.

by adding small amounts of the oil tagged with a known amount of zinc naphthenate solution. A typical calibration curve is shown in Fig. 11. By means of this calibration curve and the count rate from the circulating oil during a run, the amount of tagged oil that leaks from the sintered bushing can be determined quantitatively.

Fig. 12 shows the type of data obtained by this technique. The bushing operated at a given load for 6 hr, during which time the amount of oil leaking out of the bushing was measured. The bushing was removed and measured independently to determine how much oil remained in it. Then it was returned to the bushing test machine and measured for another 6-hr period. This procedure was continued for the duration of the test.

From the amount of oil leaking from the bushing and measurement of the activity remaining in the bushing, it was possible to determine the amount of oil remaining in the bushing as a function of time. This procedure gave two independent measurements of the oil remaining, and either method was found to be satisfactory. A plot of the oil remaining in the bushing, as determined from activity measurements, is shown in Fig. 13. This is a simple and satisfactory method to study the oil action in powdered metal bushings.

Gasket and seal evaluation

It was desired to evaluate an experimental arrangement of gaskets and seals in the cooling system of the engine, and to determine quantitatively the amount of leakage from the radiator coolant into the crankcase oil as well as the leakage site. In the past, glycol and alcohol tests have been used, but such tests are not conclusive; that is, glycol reacts with oil to some extent and makes chemical determination difficult. Alcohol vaporizes and escapes from the crankcase. Water itself does not provide a good test inasmuch as moisture may condense from water vapor contained in the crankcase. In addition to these factors, it is difficult to pinpoint the leakage site after a leak has developed.

To eliminate some of these difficulties, a radioactive tracer was added to the coolant. Cesium 134 in the form of a chloride was used. This isotope is a strong gamma emitter, has a 2.3-year half life, is water soluble, and has a high boiling point. By adding a known amount of tracer to the coolant, an accurate check for leakage into the crankcase could be made by measurement of activity increase of the crankcase oil. In addition, an opportunity for tracing the path of leakage was possible. If the leak persisted over a period of time it was hoped that particles of the tracer would be entrained along the path of leakage. Engine parts suspected of allowing leaks could then be autoradiographed on X-ray film after engine disassembly.

Pint samples of lubricating oil from the crankcase were periodically removed for radioactivity determination during the over-500 hr of test. Engine oil was changed every 120 hr. Make-up coolant was added as necessary from a make-up barrel containing the same tracer concentration as in the radiator. Results are shown in Fig. 14. Apparently, leakage began after about 175 hr of engine operation and

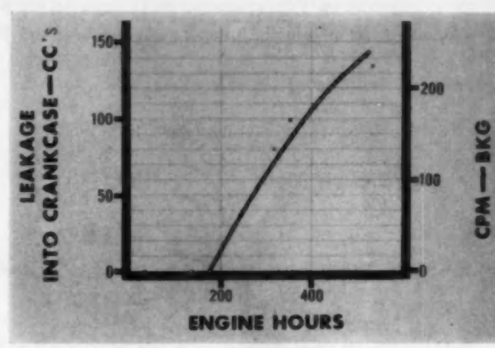


Fig. 14 — Radiator leakage as function of engine hours.

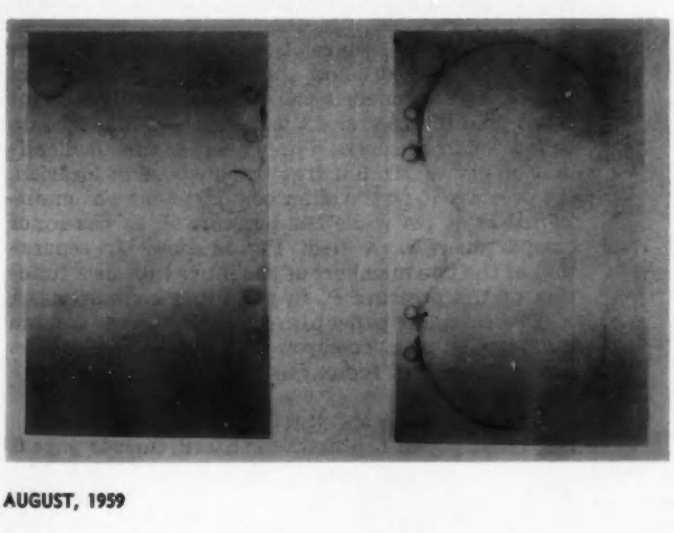


Fig. 15 — Autoradiogram of opposite sides of cylinder-head gasket.

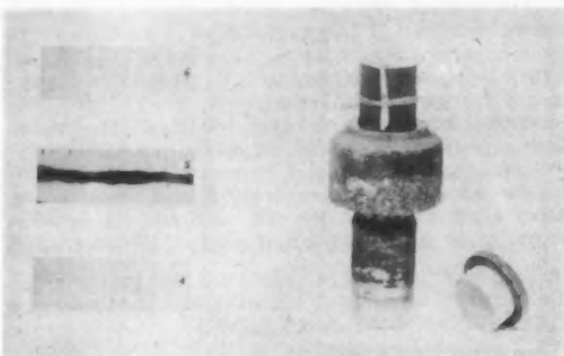


Fig. 16 — Autoradiogram of precombustion-chamber gaskets and film technique.

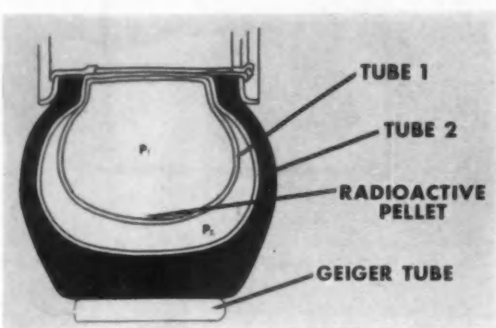


Fig. 17 — Cross-sectional diagram of composite innertube and tire.

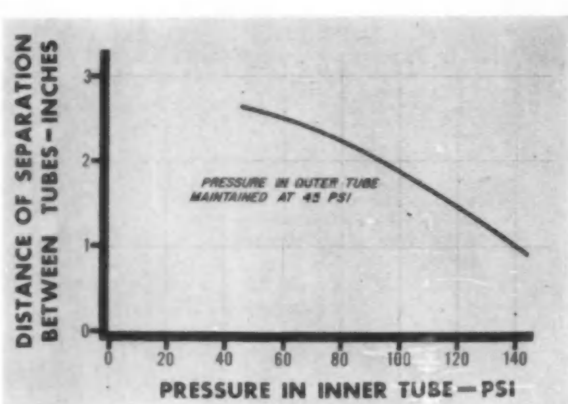


Fig. 18 — Distance of separation between tubes as function of inner tube pressure.

continued from then on approximately uniformly at an average rate of 0.5 cc per hr. After completion of the test, various gaskets and seals were evaluated by the previously mentioned autoradiographic technique. Exposures for the autoradiograms varied from 10 to 20 hr.

Reproductions of sections of the head gasket are shown in Fig. 15. The blackened exposed areas indicate presence of the tracer. The sharp dark lines indicate cracks on the bottom side of the gasket near the water holes, which could also be seen visually. Evidently, leaking and diffusion of coolant were occurring around the water holes near the cracks. The cracks may have occurred after 175 hr of operation, which could have initiated the leakage. Collection of coolant under the crimped edge on the top side of the gasket indicates possible path of leakage into the camshaft housing and oil, which was adjacent to this side of the gasket. Autoradiograms of the cylinder liner seals indicated good sealing here. There are three O-ring seals in the bottom of each liner. The top O-ring is next to the radiator coolant, while the bottom is next to oil from the crankcase. Although there was slight blackening from the center seal on some autoradiograms, this was not considered significant. The center seal was almost always dry, indicating good sealing. Autoradiograms of the precombustion-chamber gaskets (Fig. 16) indicated that one had leaked. This would have contributed to leakage into the crankcase only when the engine was not running. The tractor involved was run continuously (three-shift operation) except on weekends, when it was shut down. Improper sealing of the head gasket was considered the main cause of leakage into the crankcase during this test.

Radioactive position indicator

A measurement of an inaccessible place such as the inside of a tire can be made by means of a small radioactive pellet and a geiger counter. This is a simple means of determining the location of the inner member of a double-walled inner tube. This inner tube had two compartments, which could be individually inflated. Fig. 17 shows a cross-sectional diagram of the double inner tube in a standard tire casing. Tube 1 is suspended within tube 2. At the time, we had on hand some small radioactive iron pellets, which would drop through the valve stem of the inner member. In this figure the position of the pellet can be seen relative to the geiger counter, which was placed below the tire casing. Then, as the pellet approached the geiger tube, the count rate would increase and the position of tube 1 could be located by means of a previously established calibration curve. To illustrate the method of location, the pressure P_2 in the outer compartment was maintained at 45 psi while the pressure P_1 in the inner compartment was varied. Fig. 18 shows the separation of the two members of the inner tube as a function of the pressure P_1 in the inner compartment.

(The complete paper also covers the use of gamma radiography as a research and production tool in the earthmoving industry.)

To Order Paper No. S181 . . .
. . . on which this article is based, turn to page 6.

Jet noise starts behind the powerplant

Turbulent mixing of the jet stream and surrounding air is the major producer of jet engine noise. Sound level reductions of 15 db can be accomplished by using all of present know-how.

Based on paper by

Edmund E. Callaghan

National Aeronautics and Space Administration

CUTTING jet engine noise is solely a problem of mixing the exhaust gases with the atmosphere, cumulative tests to date show. The fact that the noise is produced behind the engine is clearly demonstrated by noise tests on experimental cold air jets.

The Lighthill theory proposes that noise is produced aerodynamically by a moving field of turbulence between the high-velocity jet from an engine and the surrounding atmosphere. In the simple case of a circular jet, the sound power generated is proportional to:

$$\frac{\rho_o A V^8}{a_o^5}$$

where:

- ρ_o = Density of ambient air
- V = Velocity of jet stream
- a_o = Local velocity of sound in ambient air
- A = Exit area of nozzle

This factor shows that the most effective control of sound can be achieved by reducing the effective velocity because of its eighth-power relationship.

There are two ways to cut the V factor, by reducing the exhaust velocity of the engine, or by speeding up the ambient air near the exhaust stream so the relative shearing velocity is cut. Bypass and

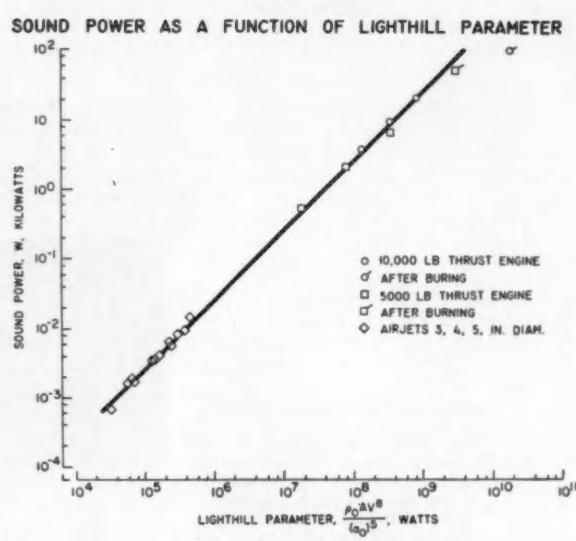


Fig. 1 — Jet engine noise is primarily caused by the jet stream mixing with the atmosphere. This is concluded from the straight-line relation between Lighthill's parameter and sound power for jet engines and cold air jets. In the latter case, there is no sound possible from internal-combustion processes, yet the test points correlate with jet engine noise. This also shows that jet velocity is the single biggest factor affecting noise.

Jet noise starts behind the power plant

. . . continued

turbo-fan engines are examples of the first solution but haven't been developed to the point of commercial usage. Fin and tube designs have been used to achieve the second solution.

The fact that the external mixing is responsible for noise is shown in Fig. 1. The Lighthill parameter is plotted against sound power on a logarithmic scale and forms a straight line with a slope of 1. This is excellent verification of the theory since jet engines and cold jets all have test points on the same line. The significance of the cold jet test points is that it eliminates the possibility of sound being generated by the combustion process or by the compressor or turbine wheels.

Cold jet studies show that the mixing of air and jet stream occurs at a very short distance downstream of a corrugated or tubed nozzle. This means that large quantities of air are induced by the pumping action very near the nozzle exit. Thus, the airflow through the valleys of the nozzle reaches high velocities and the relative velocity between the jet and the atmosphere is effectively reduced. Furthermore, the jets from the individual lobes intermix with each other as they pass downstream with small velocity differences between adjacent jets. This results in a further reduction of the intensity of the turbulent air fluctuations which cause noise. Fig. 2 shows some designs that were tested.

Ejectors aid suppression

An ejector augments suppression in two ways:

- It increases the pumping action, thereby decreasing the relative velocity at which mixing takes place.
- The inflowing air is guided in a direction more nearly parallel to the jet, which aids in reducing the noise producing shear forces between the jet and the atmosphere. In addition, the ejector provides some thrust static augmentation.

Fig. 3 shows the results of a sound test for a standard nozzle, one with eight lobes, and finally with lobes and ejector. The ejector had a diameter 1.6 times the diameter of the standard nozzle and a length that is 2.4 times the diameter. The ejector inlet was located 0.1 standard nozzle diameters downstream from the lobed nozzle inlet. Sound level data were recorded 200 ft from the nozzle exit and the jet velocity was 1700 fps. In this case, the ejector was successful in reducing the sound level below that of the standard nozzle at all points while the lobes alone were effective primarily in the rear quadrants.

Stopping the high tones

One unfortunate byproduct of multilobe nozzles, with or without ejectors, is the poor suppression performance for high-frequency sounds. This effect is

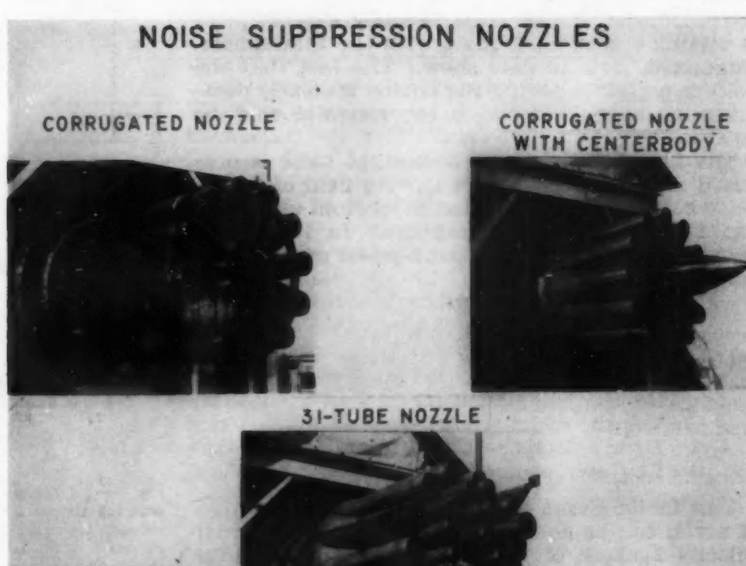


Fig. 2 — Principle of the multitube or multilobe suppressor is to suck air at high velocities between the tubes or lobes. This reduces the velocity relative to the jet and reduces sound power by the eighth power of the relative velocity. This relative velocity effect also accounts for lower sound powers when the airplane is flying.

shown in Fig. 4. The result is that the higher frequencies stay at the same level or sometimes shift to a higher energy level. Since man's hearing is very sensitive at these frequencies, the effect is to offset the large overall noise reduction achieved.

Recent tests in the high (above 500 cps) range show a 5 plus db reduction by acoustical treatment of the ejector. The inner walls were perforated and sound absorbing material was put on the inside of the ejector.

By using all the know-how now at our command, it appears possible to reduce maximum sound pressure levels of modern jet engines by as much as 15 db.

To Order Paper No. 57R . . .
. . . on which this article is based, turn to page 6.

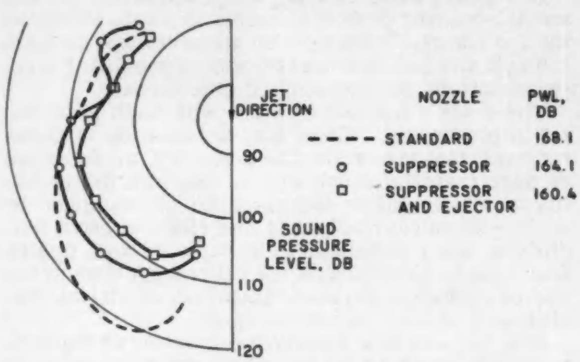


Fig. 3 — Ejectors have the effect of further reducing sound level because they aid the pumping action of the suppressor lobes. Also, the direction of flow of the "pumped" air is more nearly parallel to the jet stream as a result of using an ejector.

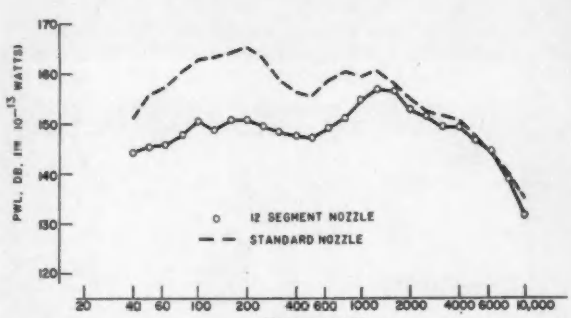


Fig. 4 — Present suppressors do not reduce sound level equally at all frequencies. In fact, the power level at high frequencies may be slightly increased in some lobe or tube designs. To combat this effect, sound absorbing materials and designs inside an ejector have proved effective.

New Fuel Flame Scale May Help Boost Jet Engine Life

LONGER life for hot parts in the combustion zone of aviation turbine engines may come from the efforts of oil companies, engine manufacturers, and a CRC committee to develop a scale to measure radiation properties of turbine fuel flames. This luminometer scale — as it is called — reveals the effect of the fuel on the working temperature of engine parts that can "see" the flame. (Past practice has been to try to control flame radiation properties by specifying smoke point or polynuclear aromatics content.)

Fuel of high luminometer number is desirable because it means lower operating temperatures of certain engine parts. In turn, this leads to their longer life. But such fuels will probably be more costly. So, studies are also being made of the economics of the higher cost fuels versus longer parts life.

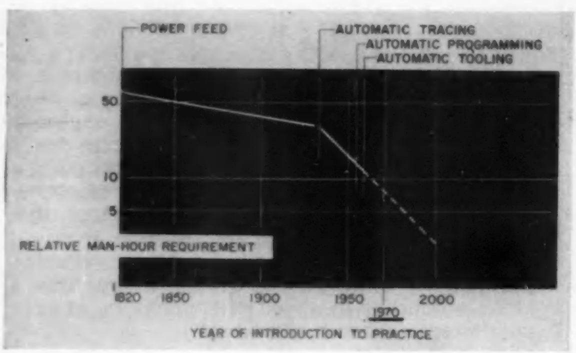
On the new "L" scale the radiant energy release of the fuel is compared with mixtures of tetralin and isooctane, with tetralin at the zero end and isooctane at 100. Because some fuels are superior to isooctane, the scale can go up to 150, or even above. Fuels that rate high on the scale are highly paraffinic and low in aromatic and naphthalene content. Many West Coast and Midcontinent crudes tend to yield turbine fuels that show up rather poorly on the luminometer scale. Kerosene fuels in current use by the airlines rate around 50 on the scale. (Mentioned at a meeting of the SAE Air Transport Activity Committee.)

Here are tomorrow's principal machining requirements — greater versatility through automatic control, improved precision through ability to machine to closer tolerances, and higher productivity in the face of rising strength levels in the work material.

Looking

Based on paper by

M. Eugene Merchant
The Cincinnati Milling Machine Co.



Automation. Man-hour requirements may once again be slashed in half by 1970. How? Perhaps through automatic design which means starting with the basic design specifications as conceived by the engineer, putting them into a computer, and from these in turn deriving the design of a finished part to fulfill specifications plus a program to operate the machine tool to produce the part.

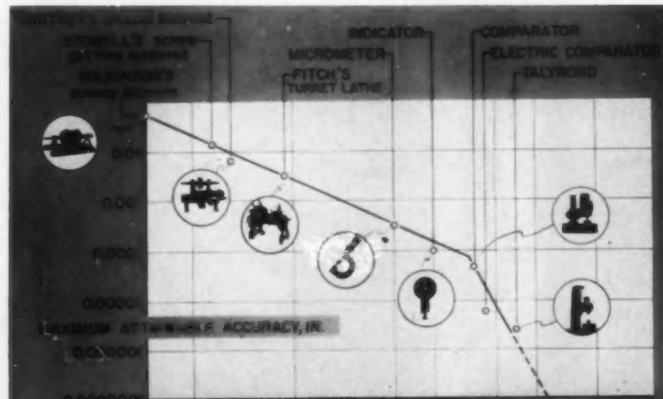
PROBLEMS IN MACHINING are increasing at an exponential rate; so has the rate of improvement in the art. Trends indicate effectiveness to have about doubled every 10 years.

But great as it has been, improvement in the metal removing process is hardly at a rate sufficient for the future. From now on advances will be more difficult and can be achieved only by mounting a research attack on well-defined objectives.

There are a number of areas with high potential for improvement. These are: automation of metal removal, tool materials and geometry, modification of work material properties in situ, and the grinding process. Electrical machining, exampled by electro-chemical machining and electron beam machining, has possibilities to be explored and, finally, there can be an attack on the general problem of the use of energy — physical, chemical, electrical, nuclear and other — to remove metal.

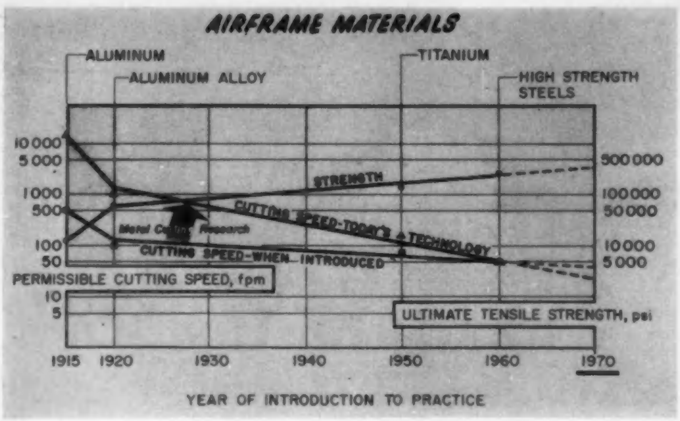
How far and how rapidly the practice of machining has been advanced and where extrapolations tell us it may be by 1970 are told in charts on this and the following pages.

To Order Paper No. 52R ...
... on which this article is based, turn to page 6.

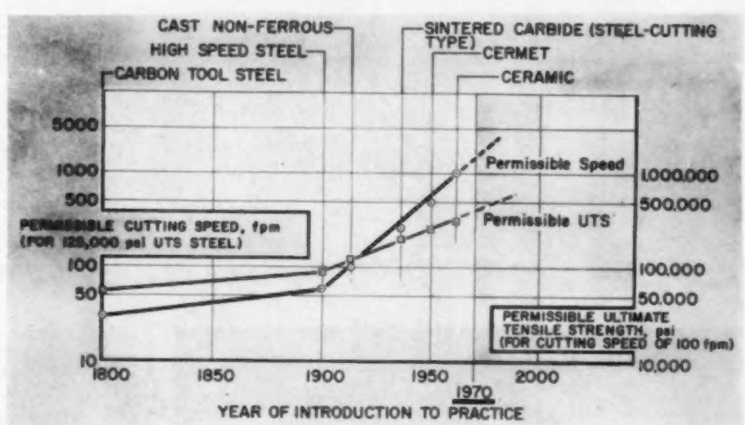


Accuracy of metal removal. While the curve of improvement shows no sign of levelling off, the size of the atom lies ahead as a strong physical limitation. We may be approaching the end point, the atom's one one-hundred-millionth of an inch, fairly rapidly but with no great detriment to future manufacture.

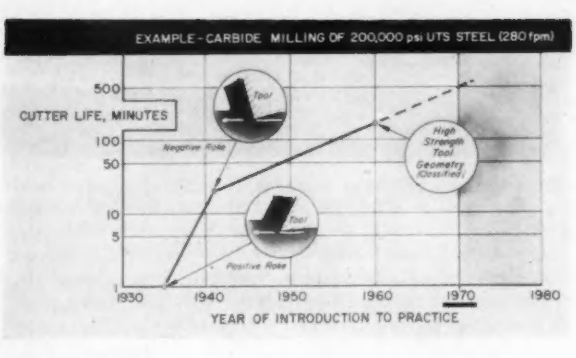
10 Years Ahead in Machining



Cutting speeds as related to material strength. Since 1920, strength of materials has increased by a factor of four but that has decreased permissible cutting speeds only by a factor of two. Without improvement in today's machining technology, permissible cutting speeds will drop by another factor of two in the next 10 years. Only by increasing the rate of improvement can permissible cutting speeds be raised.



Tool material improvement has been responsible for a doubling of the permissible cutting speed every 10 years. Although the curve shows no sign of levelling off, brittleness of tool material is becoming a limiting factor and research must devote attention to it. Nevertheless, here is an area with high potential for improvement.



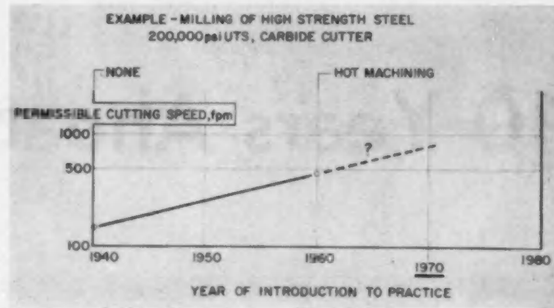
Tool geometry can be credited with tripling cutter life every 10 years and there is still room for improvement. A new development, still under wraps, is shown as promising continuing advances.

Continued

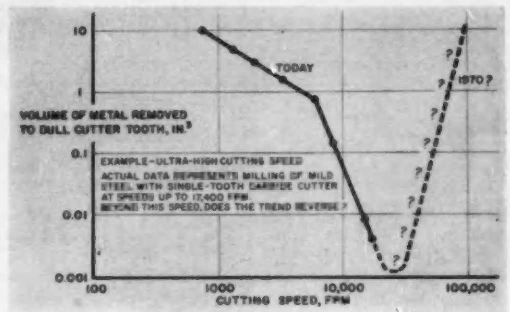
Machining

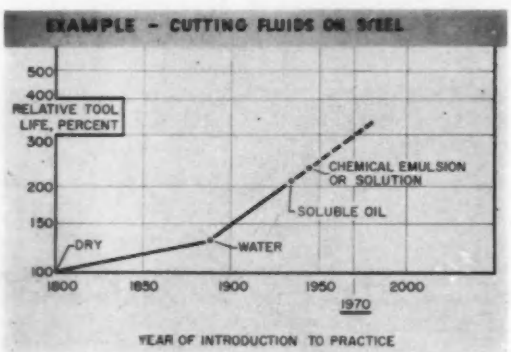
. . . continued

Modification of work material properties is a new area and a highly promising one. Hot machining, that is, local heating of the work material in a small zone just ahead of the cutter, has already permitted tripling of the cutting speed and if improvement continues at the same rate, the permissible cutting speed might double in the next 10 years. Are there other techniques such as high frequency vibration, or application of sound waves?

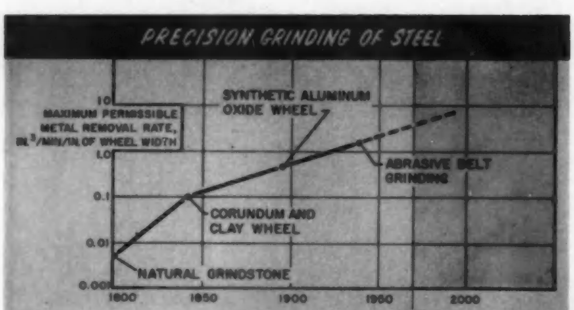


Unconventional machining conditions. Tool life decreases steadily at cutting speeds beyond 15,000 rpm, but might this behavior reverse itself at very much higher speeds? No one knows, but the answer may come from experiments being undertaken by the Air Force, Lockheed Aircraft, and others.

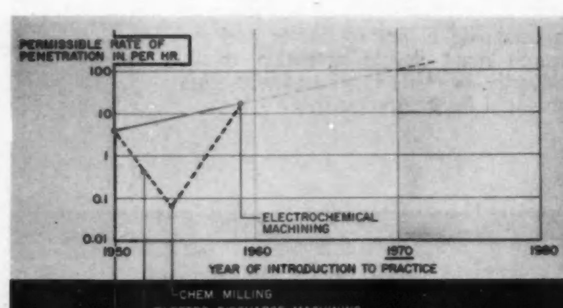




Cutting aids have shown an exponential rate of improvement, but since at best the rate has been only 20% every 10 years, this area shows the least potential for gain of any thus far examined.



The grinding process shows a 40% rate of improvement every 10 years. There is no levelling off, hence the rates of metal removal possible by this process are gradually approaching those permissible by conventional methods. In the years ahead the process may become less specialized and more general purpose in nature with consequent greater machine versatility.



Electrical and chemical methods of machining are too new to show a well-defined trend. Electro-chemical or electrolytic machining does show significant improvement in metal removal rate, there having been a fourfold improvement in rate of penetration in the past 10 years. Excellent ability to work on materials of very high strength may result in equally great improvement in the next decade.

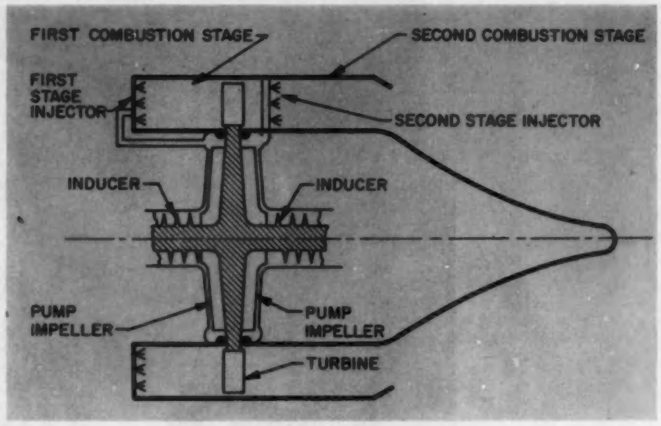


Fig. 1 — Spike nozzle thrust chamber with topping turbine and integral pump impellers illustrates concept of integrated rocket engine design.

Rocket Engine Performance . . .

. . . stands to gain more from integration of components than from further mechanical refinements.

Based on paper by

George S. Gill and Leo Kusak

Advanced Propulsion Unit, Research Subdivision, Rocketdyne

REDESIGN or refinement of existing rocket engine configuration can result in significant improvements in performance, including greater engine reliability, lower weight or volume, better thermodynamic efficiency, and reduced fabrication or operating costs.

One approach would be to integrate the components into a different overall engine configuration such that components would be very closely interrelated, with some components performing more than one function. This would result in a lighter, more compact, and simpler engine.

Component Integration

It is conceivable, for example, that turbine and pumps can be integrated into a single rotating component, as shown in Fig. 1. The turbine disc includes both the fuel and oxidizer impellers as integral parts. If necessary to cool the disc, it can be done easily by film or internal cooling. A controlled propellant leakage into the chamber would allow substitution of a liquid seal in place of a hot gas seal, at the point where the turbine joins the combustion chamber. The propellants would be separated at all times, in the pumping system, by a solid metal wall so that there would be no possibility of mixing.

The engine shown in Fig. 1 represents the final configuration of this particular integrated engine design concept and makes no pretense of being the ultimate in rocket engine configuration. Other engine systems, which may be more attractive or more practical can be arrived at in a similar manner. The major problem foreseen for this type of closely integrated engine involves the dynamic interaction among the various components, possibly resulting in serious control problems.

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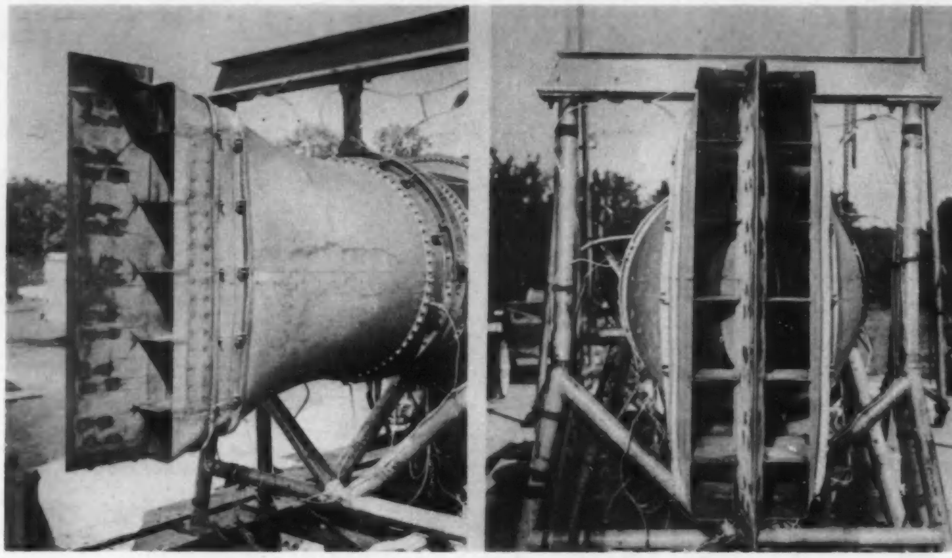

The aspect ratio-5 rectangular nozzle with turning vane installed upside down on a J57 engine for static tests.. (The large inlet bellmouth is for airflow measurement during ground runs.)

Rectangular Nozzles Cut Jet

Based on paper by

John M. Tyler and Thomas G. Sofrin,
Pratt & Whitney Division

and Jack W. Davis, Research Department
United Aircraft Corp.

RECTANGULAR nozzles (vertical slots) on jet noise suppressors bid fair to produce measurable reduction in noise radiated to the ground, recent United Aircraft studies indicate.

The elliptical noise distribution pattern which they give reduces noise going to the ground, allowing it to go to the engine sides. It is specially effective in suppressing the more-annoying, higher frequency noise bands. These suppressors also reduce the overall noise power.

This ellipticity of their noise distribution increases with higher wake aspect ratios (vertical/horizontal dimensions). So, divergent ends and a turning vane were incorporated in the experimental nozzles to increase the wake aspect ratios.

What noise should be suppressed?

Noise readings during the studies were made on a constant-altitude basis — rather than radially around the plane — because the aim was to suppress the jet noise that reaches the ground.... And, since people react to noise subjectively, the ear's frequency response had to be considered, too. Comparative annoyance was measured by the perceived noise level (PNdb) scale, which gives the high-frequency bands a little heavier weighting than does the loudness scale.

Why rectangular nozzles?

Fig. 1 points up the reason why the elliptical radiation pattern given by the rectangular nozzle cuts jet noise. It shows that less noise is radiated from the short ends (that is, groundward), than from the

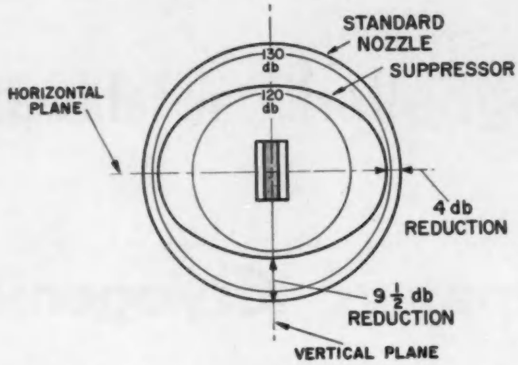

Fig. 1 — Noise levels for a standard nozzle and a rectangular nozzle suppressor. Polar plot is in a lateral plane perpendicular to the jet axis.

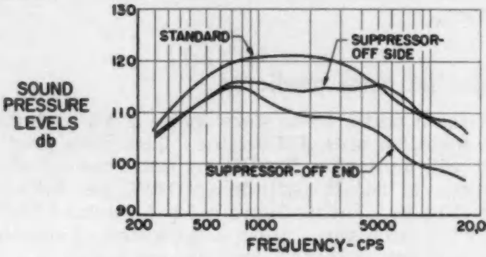

Fig. 2 — Sample spectra for the two principal planes of a rectangular nozzle, compared with a standard nozzle spectrum.

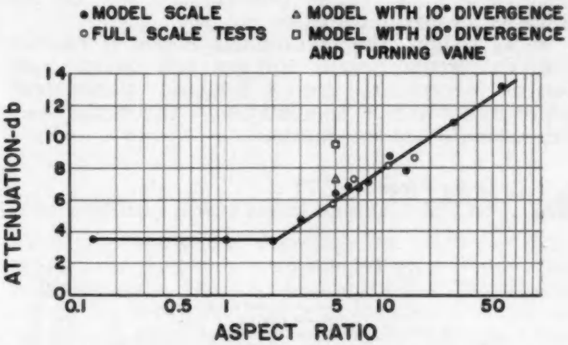

Fig. 3 — Noise reduction off the ends of rectangular nozzles at 1575 fps relative velocity, constant altitude. All models have 30-deg convergent sides.

Ground Noise

long sides. It shows also that the maximum noise level measured in the horizontal plane is actually less than that of the standard conical nozzle of equal cross-sectional area. So, there is a reduction in overall sound power.

Fig. 2 shows that the higher noise frequencies exhibit the greatest ellipticity.

How nozzle design reduces noise

These studies also show that nozzle design determines the degree of ellipticity (or noise reduction) because it affects the wake aspect ratio. For example, Fig. 3 illustrates how increasing the nozzle aspect ratio (side/end dimensions) improves noise reduction off the ends. It shows also that noise reduction is increased when the ends diverge 10 deg, and a turning vane is added to one end.

This nozzle is shown in Fig. 4; its vane is attached to a plug to improve cruise performance.

Fig. 5 proves the correlation between the wake aspect ratio and noise suppression for the nozzle de-

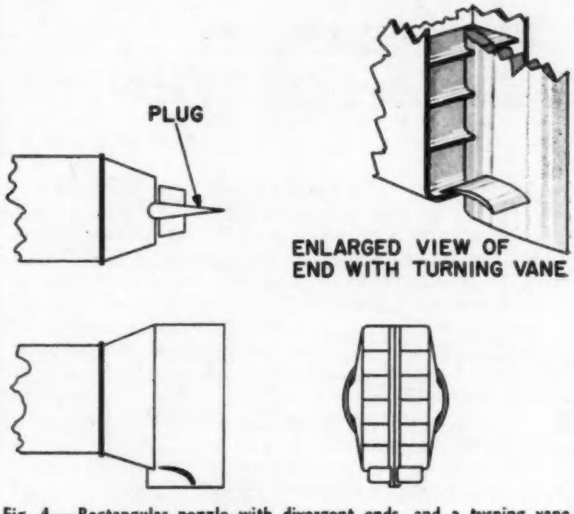

Fig. 4 — Rectangular nozzle with divergent ends, and a turning vane attached to a plug-type innerbody.

signs tested. An aspect ratio-5 nozzle was used for these tests because its shape lends itself to pod installation.

Reduced jet noise predicted

Full-scale static tests were made with a similar nozzle installed on a J57 engine. Test data predict that it will achieve a significant noise reduction — 10 PNdb — at 600-ft altitude and 70% net take-off thrust (Fig. 6). If this figure holds for actual flight, a major jet problem — noise suppression at reduced thrust and low altitude — will be overcome.

Nozzle performance and weight

Performance and weight — in addition to noise suppression — influenced nozzle design.

Studies of both external and internal flow predict that rectangular nozzle performance will be the same as for circular nozzles.

As to weight, the rectangular nozzle is heavier than the circular nozzle. But the rectangular nozzle can be incorporated into a relatively lightweight suppressor-reverser combination — the main consideration for jet transports.

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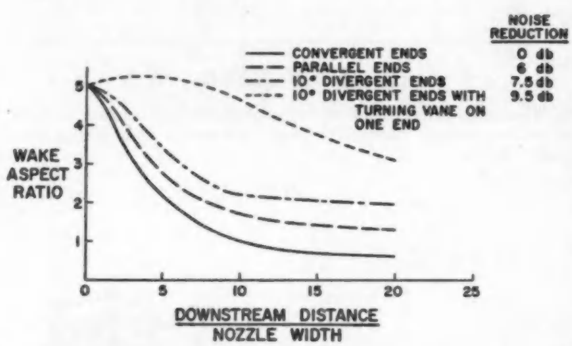


Fig. 5 — Effect of nozzle end conditions on the downstream wake aspect ratio for nozzle with an aspect ratio of 5.

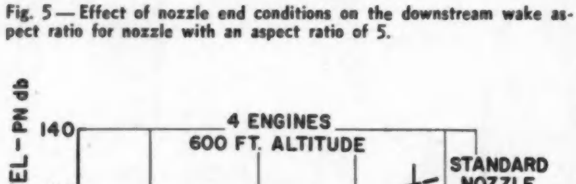


Fig. 6 — Variation of perceived noise level with jet velocity. Peak relative annoyance levels as the airplane flies overhead are shown.

Heat ... Cryogenic

Based on paper by

Daniel A. Heald
Convair (Astronautics) Division of General Dynamics

HEAT transfer causes loading and starting design problems in large missile systems powered by cryogenic propellants (fluids whose boiling points are –170 F to –423 F).

This manifests itself during loading as effective density variation, violent surface conditions, boil-off, and ice formation — problems which may be solved by insulating the tank.

And, during starting, it causes overheating and cavitation — effects which may be reduced by recirculators and subcooled charge injections.

These problem areas can be pointed up by considering a hypothetical missile system which uses liquid oxygen as one of its propellants.

Propellant Loading Problems

Effective Density Variation — In order to obtain maximum propellant loads, the liquid oxygen effective density should be known.

But this density changes markedly with temperature — thus creating a measuring problem because the heat transfer rate and temperature vary greatly in the propellant tank.

These variances arise as the tank walls and bulkhead generate warm liquid, which rises to the top; boiling reduces the surface liquid temperature, which then settles and mixes. In a vented tank the top several feet will be saturated liquid, but most of the remaining propellant may be several degrees warmer. This effect is greatly increased with adverse environment.

Transfer Challenges

Propellant System Design

Surface Conditions — This recirculation causes violent surface activity in the vented tank. In mild weather, the liquid may splash several inches, and under severe atmospheric conditions, it can splash several feet up the tank walls and out the vent valve. . . . It becomes unsafe when 100 gpm are sprayed onto the missile exterior or launch complex.

So it may become necessary to add a very precise ΔP measuring device in place of a simple level-indicator. Other additions may be baffles across the vent port, or an overflow duct to the ground support equipment.

Topping System — The propellant level will be dropping due to boiloff — this rate varies with atmospheric conditions, causing variance in replenishing requirements.

A low replenishing rate is required for average conditions, so small-diameter, well-insulated piping is used. But a much higher capacity, more rapid response system is required under adverse weather. Precise-level or mass-measuring equipment would then be required. In addition, an unusually fast response modulating valve — with wide throttling range — may be necessary.

Ice — An additional complication is the ice formation on the outside of an uninsulated tank — it may be heavy enough to affect trajectories. If this coat is retained until melted by aero-dynamic heating, a weight penalty is being paid.

Environmental Protection — Tank insulation will help solve these loading problems by yielding (1) nearly constant effective density, (2) less violent surface conditions, (3) greatly reduced boiloff, and (4) virtual elimination of ice formation.

Engine Starting Problems

Feed Line Overheating — Additional problems — such as overheating, geysering, or voiding — occur when long feed lines connect the propellant to the engine system. This is because the high surface-to-volume ratio allows rapid temperature rises with atmospheric conditions. It is also the result of a lack of circulation.

This rising temperature causes the overheating, which, in turn, may lead to geysering (similar to coffee pot percolating). If the geysering becomes explosive, the duct will be partially voided of liquid . . . . When the liquid falls back into the duct, it causes a pressure surge many times the initial pressure. Such transients may deform or rupture missile plumbing.

The usual remedy—bleeds—costs weight. Another solution is a recirculator — either external or internal. (The external circulator, however, may also cause a weight penalty unless there is more than one system to feed — and cross-over plumbing is planned anyway.)

Engine Pump Head — In order to avoid severe cavitation, the available head just prior to start may have to be triple the steady-running requirement to compensate for acceleration losses. Ullage pressures might be increased, or plumbing enlarged, to reduce inertia losses, but these changes result in increased airborne weight.

However, vapor pressure may be decreased to achieve the same results — without penalizing weight.

Subcooled Charge — Vapor pressure can be decreased by injecting subcooled propellant near the pump inlets. A simple device for doing this is a liquid nitrogen-liquid oxygen heat exchanger.

To Order Paper No. 59S . . .
. . . on which this article is based, turn to page 6.

MEMO

FROM:

Aircraft designer

TO:

Lamp manufacturer

Let's Get Together

Based on a report by **J. E. Shearer**
Boeing Airplane Co.
(Presented to SAE Committee S-14, Aircraft Lighting)

EXTERNAL LAMP LIFE on airplanes must be improved, experience with the B-52 shows. Lamp manufacturers can remedy this situation by making lamps more rugged and reporting the vibration characteristics of lamps.

An example of the problem is shown in Fig. 1. The mean life of lamps as first installed is definitely not satisfactory. This situation comes about because the aircraft designer doesn't have enough information about the lamps while the aircraft is still on the drawing board. With adequate vibration data on the lamps the designer could have relocated the lamp to a less destructive position or provided a shock mount that would protect the lamp. The ideal solution would be to have lamps rugged enough to meet the ever-increasing vibration envelopes of modern military aircraft.

At the start of an aircraft design, the vibration characteristics can be reasonably approximated. The acoustic noise produced by the engines and the aerodynamic disturbances are calculated and plotted for various areas of the wing and fuselage. An example of this type of information is shown in Fig. 2. With this type of data available early in the design stage, the lamp life problem can be solved if corresponding data are available on lamps.

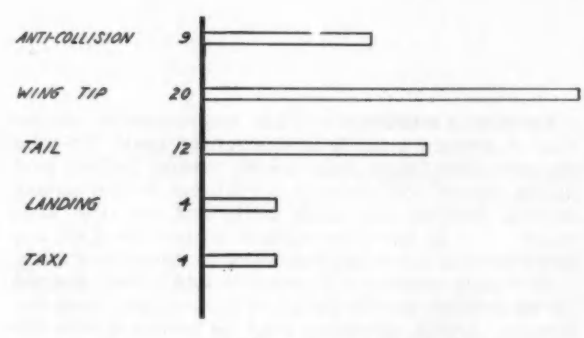


Fig. 1 — Lamp life fell far short of what was anticipated when the B-52A was first flown. The normal energized rating without vibration for these lamps is 25 hr for landing lights and about 300 hr for all others.

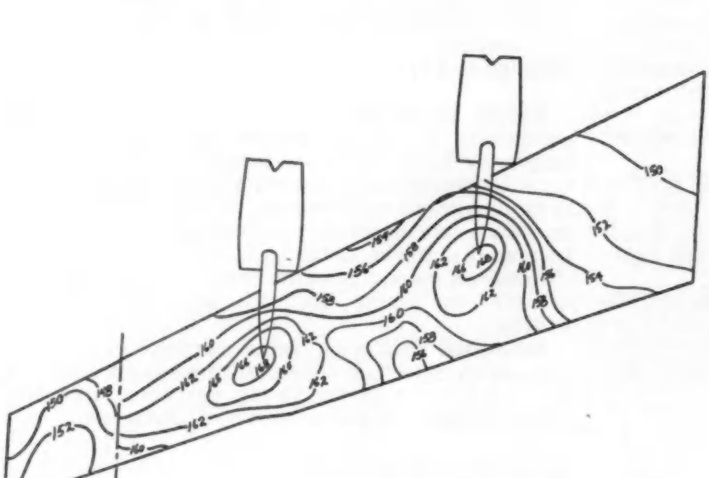


Fig. 2 — Vibration information is available at an early stage of aircraft design. The diagram shows a typical sound level plot in db for the B-52. From this type of information the vibration envelope of proposed lamp sites can be found. With this data, the proper lamps could be chosen or a good lamp-shock mount combination selected, provided corresponding vibration data are available for lamps.

Air Force program evaluates

the machining characteristics of a

Stainless Steel

Based on paper by

P. R. Arzt, J. V. Gould, and J. Maranchik, Jr.

Metcut Research Associates, Inc.

AN Air Force research program is providing valuable data on machining the martensitic low-alloy steels, hot-work die steels, and martensitic stainless steels in the high hardness ranges.

This article discusses results, to date, obtained with A-286 austenitic stainless steel, solution treated and aged.

Turning tests

Turning proved to be the least difficult of the various types of machining operations being studied for the ultra-high-strength thermal-resistant alloys. It was possible to obtain reasonable tool life in turning without resorting to unusual types of tools, tool geometries, or techniques. Good tool life results can be obtained by adhering to the following general recommendations:

1. Use a rigid machine, and strong, solid tools and fixtures.
2. Use the proper type of carbide. For a given type of carbide, select the hardest grade that will perform without chipping.
3. Use cutting speeds, feeds and tool geometries

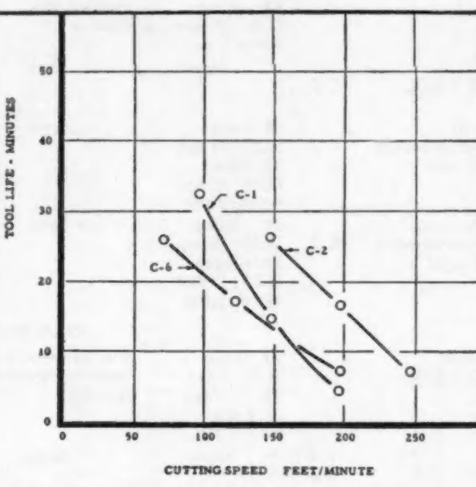


Fig. 1 — Turning A-286, solution treated and aged to 314 Bhn (33 Rockwell C). Tool: carbide (see graph); side rake: 5 deg neg.; back rake: 5 deg neg.; nose radius: 0.032 in.; side cutting edge angle: 15 deg; end cutting edge angle: 15 deg; relief: 5 deg. Mechanical chip breaker. Feed 0.009 in. per rev.; depth: 0.100 in.; cutting fluid: none; wearland: 0.015 in.

THIS ARTICLE on A-286 stainless steel, solution treated and aged, is the result of an Air Force program set up to evaluate the machining characteristics of the more commonly used high-strength thermal-resistant materials.

The work is being performed by Metcut Research Associates, Inc. under contract to Wright Aeronautical Division of the Curtiss-Wright Corp.

The other three materials tested under this program were discussed in previous articles in SAE Journal, as follows:

SAE 4340 (AISI 4340) was covered in the May issue.

SAE designation H11 (which is equivalent to the Vasco Jet 1000 referred to in the article) was covered in the June issue.

AM-350 was covered in the July issue.

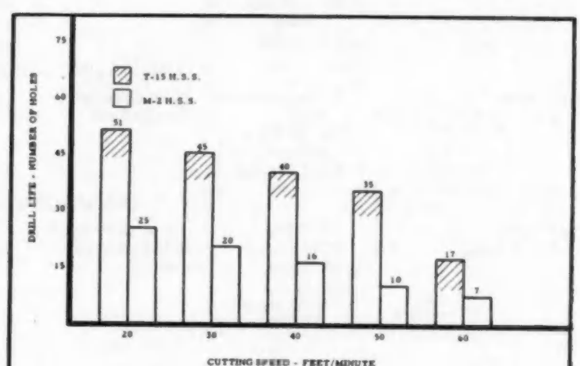


Fig. 2 — Drilling A-286 solution treated and aged to 321 Bhn; effect of tool material. Drill: see graph; diameter: 0.250 in.; length: 4 in.; point angle 118 deg; helix angle: 29 deg; crankshaft clearance: 7 deg; depth of hole: 0.500 in.; cutting fluid: highly sulfurized oil diluted 1: 1 with light machine oil; feed 0.005 in. per rev.; wearland 0.015 in.

Stainless Steel

... continued

selected from turning data obtained under controlled cutting conditions.

Tool life results for turning A-286 solution treated and aged to 33 R_c are shown in Fig. 1.

Drilling tests

The drilling tests performed on the ultra-strength

Machining Data for

Material	Tool Material	Tool Geometry	Cutter	Depth of Cut	Width of Cut	Feed	Cutting Speed	Tool Life	Wear-land	Cutting Fluid
			TURNING — CARBIDE TOOLS							
SAE 4340 Q & T-52 R_c	C-8	SR: – 5 deg SCEA: 15 deg BR: – 5 deg ECEA: 15 deg Relief: 5 deg	½ in. sq. throwaway holder with mechanical chip breaker	0.100 in.	—	0.009 in. per rev.	150 fpm 300 fpm	47 min 10 min	0.016 in.	None
H11 Q & T-52 R_c	C-8	Same	Same	0.100 in.	—	0.009 in. per rev.	100 fpm 200 fpm	50 min 10 min	0.016 in.	None
AM-350 Solution treated and aged	C-2	SR: 5 deg SCEA: 15 deg BR: 0 deg ECEA: 15 deg Relief: 5 deg	Same	0.100 in.	—	0.009 in. per rev.	150 fpm 200 fpm	60 min 5 min	0.016 in.	None
A-286 Solution treated and aged	C-2	SR: – 5 deg SCEA: 15 deg BR: – 5 deg ECEA: 15 deg Relief: 5 deg	Same	0.100 in.	—	0.009 in. per rev.	150 fpm 250 fpm	25 min 7 min	0.016 in.	None
			FACE MILLING — CARBIDE TOOLS							
SAE 4340 Q & T-52 R_c	C-6	AR: 0 deg ECEA: 5 deg RR: – 15 deg Cl: 8 deg CA: 45 deg	5 in. diameter, 5-tooth inserted tooth face mill	0.100 in.	2 in.	0.005 in. per tooth	150 fpm 225 fpm	330 in. 180 in.	0.016 in.	None
H11 Q & T-52 R_c	C-2	Same	Same	0.100 in.	2 in.	0.005 in. per tooth	125 fpm 175 fpm	400 in. 100 in.	0.016 in.	None
			SIDE MILLING — CARBIDE TOOLS							
SAE 4340 Q & T-52 R_c	C-6	AR: – 5 deg ECEA: 5 deg RR: – 10 deg Cl: 8 deg CA: 45 deg	7 in. diameter, 6-tooth inserted tooth face mill	0.100 in.	1¾ in.	0.0075 in. per tooth	150 fpm 220 fpm	380 in. 75 in.	0.016 in.	None
H11 Q & T-52 R_c	C-2	AR: 0 deg ECEA: 5 deg RR: – 15 deg Cl: 8 deg CA: 45 deg	Same	0.100 in.	1¾ in.	0.0075 in. per tooth	150 fpm 260 fpm	390 in. 90 in.	0.012 in.	None
			END MILLING — HIGH SPEED STEEL TOOLS							
SAE 4340 Q & T-49 R_c	T-15	35 deg right hand helix CA: 45 deg × 0.060 in. Per. Cl.: 6 deg	¾ in. diameter, 4-flute end mill	0.250 in.	¾ in.	0.001 in. per tooth	55 fpm 80 fpm	70 in. 30 in.	0.016 in.	Soluble oil flood (20:1)
			END MILLING — CARBIDE TOOLS							
SAE 4340 Q & T-52 R_c	C-2	AR: 0 deg ECEA: 3 deg RR: 0 deg Cl: 15 deg CA: 45 deg × 0.030 in.	1¼ in. diameter, 4-flute brazed tip end mill	0.250 in.	1¼ in.	0.0015 in. per tooth	50 fpm 80 fpm	78 in. 40 in.	0.016 in.	Chemical emulsion* (40:1)
H11 Q & T-52 R_c	C-2	Same	Same	0.250 in.	1¼ in.	0.0015 in. per tooth	60 fpm 150 fpm	105 in. 55 in.	0.016 in.	Soluble oil* (20:1)

Q & T = Quenched and tempered
R_c = Rockwell C hardness
SR = Side rake
BR = Back rake
AR = Axial rake

RR = Radial rake
SCEA = Side cutting edge angle
ECEA = End cutting edge angle
CA = Corner angle
Cl = Clearance

Per. Cl. = Peripheral clearance
* Applied as spray mist through axis of cutter.

alloys consisted of drilling ¼ in. diameter by ½ in. deep through holes. Drill life end point was an arbitrary 0.015 in. wearland on the drill margin or complete breakdown, whichever occurred first.

Good drill life was obtained in drilling 321 Bhn A-286 using T-15 drills with a crankshaft point, cutting speeds of 20–40 fpm, a feed of 0.005 in. per rev., and a highly sulfurized oil (Fig. 2).

Summary

The table on these pp. summarizes machining data on the four ultra-strength alloys discussed in this and the three prior issues of SAE Journal.

To Order Paper No. 43R ...
... on which this article is based, turn to page 6.

Ultra Strength Alloys

Material	Tool Material	Tool Geometry	Cutter	Depth of Cut	Width of Cut	Feed	Cutting Speed	Tool Life	Wear-land	Cutting Fluid
SLOTTING — CARBIDE TOOLS										
SAE 4340 Q & T-52 R_c	C-2	AR: – 5 deg ECEA: 1 deg RR: – 10 deg Cl: 8 deg CA: 45 deg × 0.030 in.	6 in. diameter, 6-tooth brazed tooth slotting cutter	0.250 in.	1 in.	0.005 in. per tooth	190 fpm 275 fpm	225 in. 150 in.	0.016 in.	None
H11 Q & T-52 R_c	C-2	Same	Same	0.250 in.	1 in.	0.005 in. per tooth	190 fpm 350 fpm	300 in. 180 in.	0.012 in.	None
DRILLING — HIGH SPEED STEEL TOOLS										
SAE 4340 Q & T-50 R_c	T-15	2-flute, 118 deg crankshaft point 7 deg clearance	¼ in. diameter stub drill	0.500 in. through hole	—	0.001 in. per rev.	30 fpm 60 fpm	100 holes 20 holes	0.016 in.	Highly sulphurized oil + light machine oil (1:1)
SAE 4340 Q & T-52 R_c	T-15	Same	Same	0.500 in. through hole	—	0.001 in. per rev.	20 fpm 60 fpm	34 holes 8 holes	0.016 in.	Same
H11 Q & T-52 R_c	T-15	Same	Same	0.500 in. through hole	—	0.0005 in. per rev.	20 fpm 60 fpm	26 holes 7 holes	0.016 in.	Same
AM-350 Solution treated and aged	T-15	Same	Same	0.500 in. through hole	—	0.002 in. per rev.	20 fpm 60 fpm	107 holes 28 holes	0.016 in.	Same
A-286 Solution treated and aged	T-15	2-flute, 118 deg crankshaft point 7 deg clearance	Same	0.500 in. through hole	—	0.005 in. per rev.	20 fpm 60 fpm	51 holes 17 holes	0.016 in.	Same
TAPPING — HIGH SPEED STEEL TOOLS										
SAE 4340 Q & T-50 R_c	M-10	4-flute 60% thread	5/16-18 NC taper tap	0.500 in. through hole	—	—	5 fpm 20 fpm	146 holes 30 holes	Tap break-age	Highly chlorinated oil
	M-10	4-flute 75% thread	Same	Same	—	—	5 fpm	13 holes	Tap break-age	Same
SAE 4340 Q & T-52 R_c	M-10	4-flute 60% thread	Same	Same	—	—	5 fpm	75 holes	Tap break-age	Inhibited trichloroethane
	M-10	Same	Same	Same	—	—	5 fpm	7 holes	Tap break-age	Chlorinated oil + inhibited trichloroethane (3:1)
	M-10	4-flute 60% thread 0.015 in. land	Same	Same	—	—	5 fpm	18 holes	Tap break-age	Same
AM-350 Solution treated and aged	M-10	4-flute 75% thread	Same	Same	—	—	5 fpm 9 fpm	200 + holes 25 holes	Tap break-age	Highly chlorinated oil

Q & T = Quenched and tempered
R_c = Rockwell C hardness
SR = Side rake
BR = Back rake
AR = Axial rake
RR = Radial rake
SCEA = Side cutting edge angle
ECEA = End cutting edge angle
CA = Corner angle
Cl = Clearance

Two design tips for

Evaporation Cooling of Hypersonic

Based on paper by

ELI KAPLAN

Republic Aviation Corp.

Tip No. 1

How Much Insulation?

A quick mathematical check will give the optimum insulation thickness of an evaporative cooling system. This will result in the lowest weight for the combination of coolant and insulation for each system investigated.

Three common structural forms are flat plates, cylinders, and spheres. The equations for these forms are:

Flat Plate

$$\int_0^{\theta_t} \frac{k\,\Delta T\,d\theta}{\left(X_m+\frac{k}{h}\right)^2} = \frac{\rho L}{12}$$

where:

X_m = Insulation thickness for minimum combined weight of insulation and coolant, in.

k = Thermal conductivity of insulation, Btu-in./hr-ft^2-F

ΔT = Temperature differential across wall of cooled compartment, F

θ = Time, hr

θ_t = Total flight duration, hr

h = Internal convection heat transfer coefficient, Btu/hr-ft^2-F

L = Evaporant latent heat of vaporization, Btu/lb

ρ = Insulation density, lb/ft^3

The equation is solved for X_m by trial and error once the time variations of k, ΔT, and h are known. The analysis assumed that cooling is accomplished by the latent heat of evaporation.

A simplified version of the flat plate solution is:

$$X_m = \sqrt{\frac{12\,\bar{k}\,\overline{\Delta T}\,\theta_t}{\rho L}}$$

In this case, $\bar{k}$ and $\overline{\Delta T}$ are average values and k/h is assumed to be small compared to X_m. This solution results in equal weights of insulation and evaporant, which makes a convenient rule of thumb.

Cylinder

$$\int_0^{\theta_t} \frac{k\,\Delta T\,d\theta}{\left[\frac{kr_o}{hr_i}+r_o\ln\frac{r_o}{r_i}\right]^2} = \frac{\rho L}{12}$$

where:

r_o = Outside radius of insulation, in. (the unknown)

r_i = Inside radius of insulation, in.

Sphere

$$\int_0^{\theta_t} \frac{r_i^4\,k\,h^2\,\Delta T\,d\theta}{r_o^2[r_i h(r_o-r_i)+kr_o]^2} = \frac{\rho L}{12}$$

Tip No. 2

Overboard Duct Size

Ducting the evaporant overboard can be done with the least weight of ducting when the exit velocity is critical (Mach No. = 1.0). The two cases that are typical are:

- Adiabatic flow through the duct (representative of internal ducting with insulation).
- Constant wall temperature (representative of ducting made integral with the skin of the vehicle).

The solutions for these two conditions are given in Figs. 1 and 2. The results are found in terms of a plot of duct diameter and Mach number, as shown in the following example.

Problem

Find the duct areas for the following high-speed flight vehicle, both for adiabatic flow and constant wall temperature.

Conditions

A compartment is evaporatively cooled with water. The compartment pressure is maintained at 1 psia and the evaporant temperature is approximately 101 F. The vapor must be conveyed to an overboard discharge point that requires a run of ducting approximately 120 inches long. The total compartment cooling load due to external heat transfer and internally generated heat is 50 kw. The duct may be internal or integrated with the vehicle skin. In the latter case, the temperature of the duct wall is calculated to be approximately 1200 F. The ratio of absolute duct wall temperature, 1660 R, to the absolute initial vapor temperature, 561 R, is almost 3 to 1.

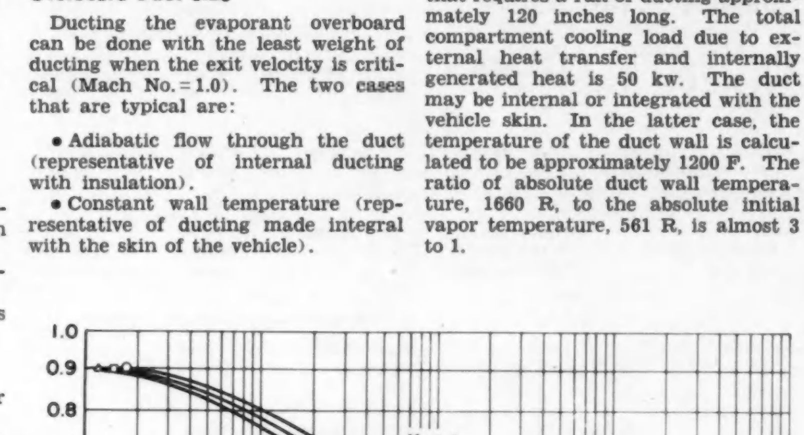


Fig. 1 — Solution for adiabatic friction flow through a duct is plotted for various values of specific heat, γ. Outlet of the duct is critical. Length of duct is *L*, hydraulic diameter is *D*, and friction factor is *f*. Mach number is for the inlet.

figuring

Vehicles

Constant Wall Temperature Solution

γ for the steam vapor is 1.322. The gas constant R for the steam is taken as 86 ft/R and the latent heat of vaporization is 1000 Btu/lb.

The rate of steam production is:

$$50\ \text{kw} \times 0.95 \frac{\text{Btu}}{\text{sec-kw}} \times \frac{1\ \text{lb}\ H_20}{1000\ \text{Btu}} = 0.0474 \frac{\text{lb}}{\text{sec}}$$

The weight flow per unit area of a gas in a duct as a function of Mach number, total pressure, and temperature is given by:

$$\frac{W}{A} = \sqrt{\frac{g\gamma}{R}}\frac{P_o}{\sqrt{T_o}} \frac{M}{\left(1+\frac{\gamma-1}{2}M^2\right)^{\frac{\gamma+1}{2(\gamma-1)}}}$$

where:

W = Flow, lb/sec
A = Flow area, in.^{2}
g = Acceleration of gravity, ft/sec^2
γ = Specific heat ratio, c_p/c_v
R = Gas constant, ft/R
P_o = Total pressure, psia
T_o = Total temperature, R
M = Local Mach number

The fluid inlet Mach number as a function of the duct diameter may now be calculated.

Substituting $\gamma = 1.322$, $R = 86$ ft/R, $P_o = 1$ psia, $T_o = 561$ R, and arbitrarily assuming $M = 0.3$, W/A is determined to be 0.0087 lb/sec-in.^{2} For the flow of 0.0474 lb/sec, the duct area would be $\frac{0.0474\ \text{lb/sec}}{0.0087\ \text{lb/sec-in.}^2} = 5.44$ in.^{2} corresponding to a 2.63-in. diameter if the duct is round. Similarly for other assumed Mach numbers, corresponding duct diameters are calculated and the Mach number versus duct diameter function is plotted.

Another Mach number-duct diame-

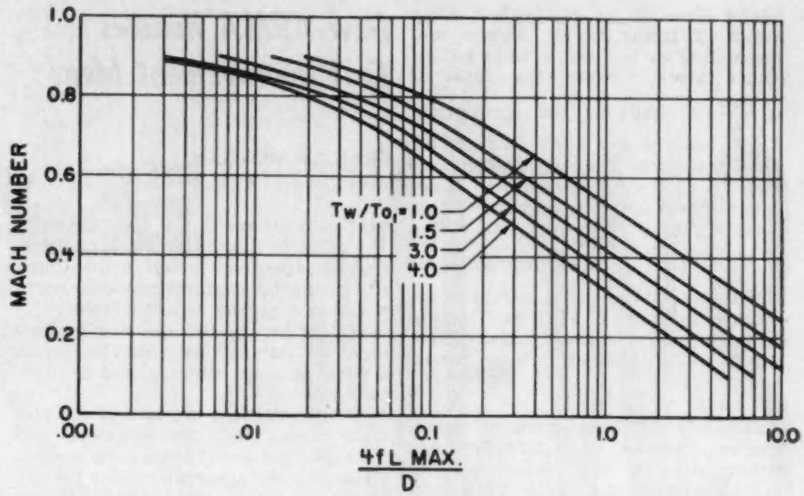


Fig. 2a — $\gamma = 1.2$

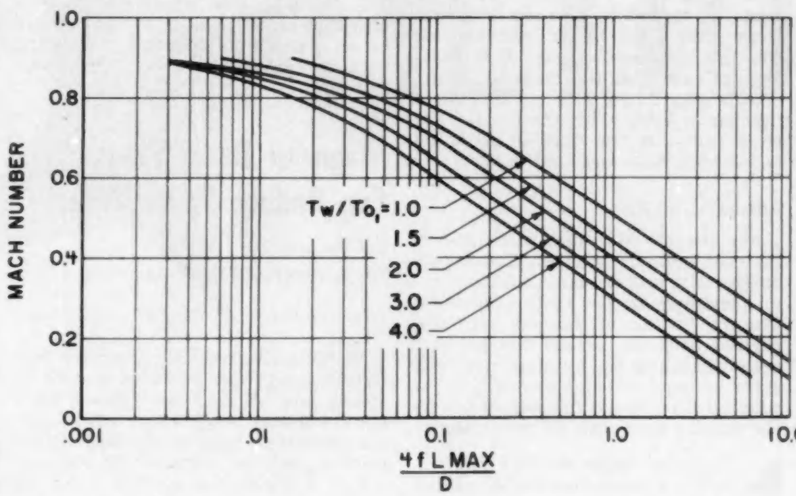


Fig. 2b — $\gamma = 1.4$

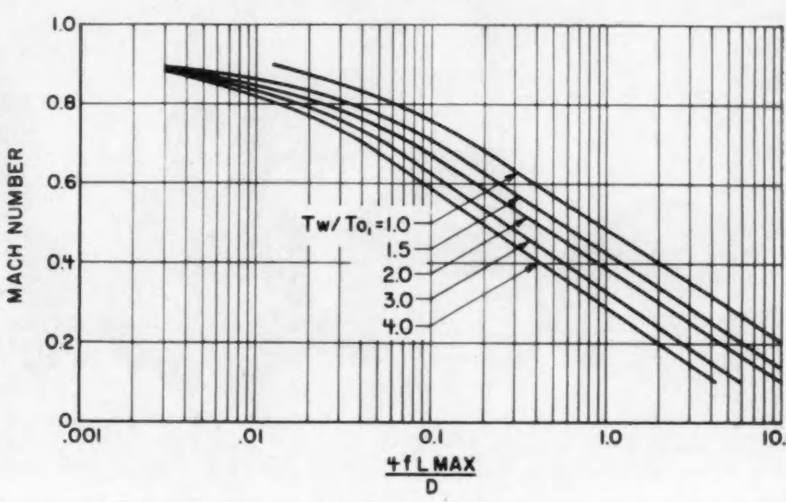


Fig. 2c — $\gamma = 1.6$

Fig. 2 — Adding heat by keeping the wall of a duct at constant temperature produces a series of solutions for the choking length of a duct. The solutions are calculated from the differential equations by using the Reynold's Number analogy. T_{o_1} is inlet total temperature and T_w is the wall temperature.

ter relationship is established using Fig. 2. Entering the Fig. 2 curve corresponding to the gas γ with an assumed Mach number, the value of $4f\,\frac{L_{max}}{D}$ is read for the appropriate T_w/T_{e_1} (which has been given as 3.0 in our example). Since we must consider $\gamma = 1.322$, it is necessary to interpolate between Fig. 2a and 2b. Interpolating linearly for $\gamma = 1.322$ gives $4f\,\frac{L_{max}}{D} = 1.448$. The corresponding diameter is then solved for, assuming an average value of $f = 0.005$ and setting L_{max} equal to the given 120-in. duct length. The diameter then equals $\frac{4 \times 0.005 \times 120}{1.448}$, or 1.66 in.

Similarly, for other assumed Mach numbers corresponding diameters are determined and are plotted on the same graph as the values previously plotted from the weight flow per unit area equation. The intersection determines that duct diameter and corresponding inlet Mach number that will just produce choking. It is found for our case that the diameter is approximately 2.5 in. with an inlet Mach number of 0.35. This then is the size requirement if the duct is made integral with skin and structure.

Adiabatic Solution

For the internal duct with little or no heat transfer a Mach number-diameter plot may be derived from Fig. 1 in a manner similar to the foregoing. The intersection of this plot with that derived from the weight flow per unit area equation is the solution. Our case gives a required diameter of 2.0 in. with an inlet Mach number of 0.5 for the interior duct with no heat transfer.

To Order Paper No. 54T . . .
on which this article is based, see p. 6.

How ARMA Handles Cost Improvement Ideas

Excerpts from paper by

FRANK J. MORGAN

Arma Division, American Bosch Arma Corp.

WHEN a proposal for cost improvement is submitted at Arma Division of American Bosch Arma Corp., the industrial engineering department analyzes it on the following basis:

1. Cost for the old and new method and gross savings are computed on an annual basis at contemplated production rates.

2. All estimated direct and indirect labor hours for old methods, new methods, and installation costs are extended by the appropriate rate for the grade of labor involved, excluding side payments.

3. An employee expense factor is added to all labor costs to compensate on an average basis for side payments, vacations, holidays, payroll taxes, compensation insurance, retirement and group insurance . . . and that part of perishable tool supply, repair and miscellaneous expense which tends to vary indirect proportion to manpower.

4. Total installation costs — which are deducted from annual gross savings to find net savings — include material, labor and labor-compensating factor for the tooling. . . also rearrangement and other necessary expense items . . . also 20% of any capital expenditures required by the change.

5. Determine whether net savings are 15% or more of the total installation cost. When they are, installations are not normally made.

6. Include applicable burden for Arma personnel when comparing to costs of outside operations through vendors or subcontracting.

This analysis then goes to a cost improvement committee. If the cost improvement proposal is accepted by this committee, the committee chairman forwards a letter of acceptance to the department manager for presentation to the originator. Members of this

continued on page 118

Magnetic Drain Plugs Can Reduce Parts Wear

Based on paper by

W. A. JOHNSON, Rockwell Standard Corp.

(Presented before SAE Mid-Continent Section)

A WORKING drive axle generates very fine, hard, wear particles at a fairly steady rate. If they are removed from the circulating lubricant as fast as they are generated, wear of the antifriction bearings will be substantially reduced. Fig. 1 shows the particle-removing capacity of various types and sizes of magnets in a 60-min laboratory test run.

Field tests with trucks have also demonstrated the wear reducing capacity of magnetic drain plugs. Observing that end play developed in the various tapered-roller bearings to a degree necessitating readjustment at approximately 100,000 miles, magnetic plugs were installed and changed at monthly intervals. After that, all vehicles were able to run over 200,000 miles before the same amount of end play developed.

To Order Paper No. S198 . . .
on which this article is based, see p. 6.

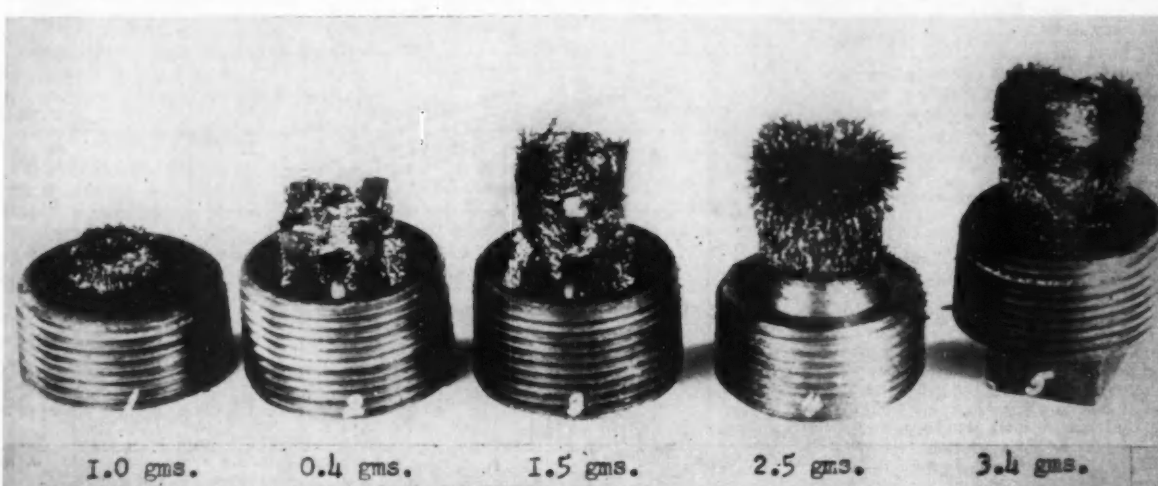


Fig. 1 — Contamination pickup of magnetic drain plugs in drive axles. Each magnet was tested in a clean axle with a 5-g charge of magnetically separated, fine-grinding, hard-steel particles in the lubricant.

SAE NEWS

President and Mrs. Leonard Raymond

SAE President Raymond . . .

. . . to be guest of 8 European engineering societies in 6 countries.

THE Society of Automotive Engineers will mean more to more engineers and industrialists in Western Europe at the end of 1959. By that time, SAE President Leonard Raymond will have completed his currently planned extensive trip through Europe as "SAE Ambassador of Goodwill."

Starting in the latter part of September, President Raymond will visit with members, and speak at meetings, of eight engineering societies in six European countries. His public appearances will provide SAE members in Europe with the opportunity of meet-

President Raymond Will Also Participate in Meetings of:

Country	Society	Date	Time	Place	President Raymond's Participation
England	Institution of Mechanical Engineers, Automobile Division	Oct. 6 Tues.	evening	London	Honor guest at meeting and dinner of Automobile Division of Institution of Mechanical Engineers
England	Institute of Petroleum	Oct. 7 Wed.	evening	Ritz Hotel London	Honor guest at General Meeting and Dinner of Institute
France	Société des Ingénieurs de l'Automobile	Oct. 19 Fri.	early in day	Airport	President Raymond to be welcomed at Airport by Past-Presidents of SIA
France	Institut Francais du Pétrole	Oct. 21 Wed.	Noon	Rueil-Malmaison	Honor guest at luncheon and presentation of talk on present and future research problems on automotive products in the petroleum industry
Germany	Verein Deutscher Ingenieure	Oct. 29 and 30 — Turs. and Fri.		Stuttgart	Presentation of paper titled "Cooperation in Research — The Story of American Automotive and Petroleum Industry Engineering Progress," at meeting of the VDI-Fachgruppe Automotive Engineering

Schedule of President Raymond's Presentations to European Engineering Societies

(Meetings to Which SAE Members Are Invited)

Country	Society	Date	Time	Place	President Raymond's Participation
Holland	Motor Technisch Colloquium	Sept. 24 Thurs.	2:00 p.m.	Hotel Smits Vredenburg Utrecht	Presentation of technical talk on mutual research problems of the American automotive and petroleum industries at meeting of Colloquium
Italy	Associazione Tecnica Automobile	Oct. 14–15 Wed. and Thurs.		Milano	Honor guest and presentation of paper titled "Mutual Problems of American Automotive and Petroleum Research," at ATA Milan Congress Meeting
France	Société des Ingénieurs de l'Automobile	Oct. 20 Tues.	5:00 p.m.	Paris	Presentation of talk titled "Cooperation Between the Automotive and Petroleum Industries in Technical Developments and the Role of SAE in Serving Industry"
England	Institution of Mechanical Engineers, Automobile Division	Oct. 27 Tues.	6:00 p.m.	Institution of Mechanical Engineers, 1 Birdcage Walk London	Presentation of paper titled "Engineering Challenges to American Automotive and Petroleum Research," to Automobile Division of IME

ing personally their Society's top executive for 1959.

In addition to his informal contacts with European engineering societies and their officers, President Raymond's itinerary will bring him to numerous European plants. His travels will also include visits with industrial executives in six countries.

President Raymond will participate in meetings of the societies he will visit. As shown in the partial itinerary tabulated below, he will present papers in Holland, England, Italy, France, and Germany. In each case, President Raymond will present a paper tailored to the specific audience and its interests. For instance, the paper he will give to the Institution of Mechanical Engineers, Automobile Division, will be titled "Engineering Challenges to American Automotive and Petroleum Research."

President Raymond is also planning to visit Sweden during the last week in September. Plans have not, as yet, been finalized for the presentation of a paper.

Arrangements have been worked out with a number of the European engineering societies to permit SAE members to attend their meetings, so as to permit overseas members to meet their President. This, too, is shown in the tabulation below.

Advance contacts indicate that a warm reception is in store for the SAE President at all ports of call. Mr. Raymond is delighted with the enthusiastic invitations he has received and the indications of plans to receive him in the various countries he will visit.

Mrs. Raymond will accompany the President on his trip abroad.

SAE's Public Relations Means SAE Members at Work

Presented to SAE Council by **A. B. Hegner**

SAE Public Relations Committee

PUBLIC relations is many things to many people. One public relations expert defines it as shuffling prejudices so that yours comes out on top. Another views public relations as the creation of a favorable and receptive environment within which to operate.

Each has his own definition of public relations and, in part, I am sure it applies to SAE.

What is SAE's public relations program? This was perhaps best expressed to Council on Jan. 11, 1946, by Ray Kelly, the first Public Relations Committee Chairman, when he said,

> "It should be understood that our conception of public relations activity is definitely not press-agentry. Its success is not to be measured by square inch of publicity space wrung from newspapers and periodicals; but rather by the recognition which the Society has won in rank and file of engineers and foreign organizations; among students and mechanics, salesmen and purchasers of automotive apparatus.

> "Then, too, the work of other committees, Activities and Sections has been aided by the greater readiness with which individuals and organizations have been induced to cooperate to make our meetings and the deliberations of our committees successful."

Public Relations Committee Chairman Horine in reporting to Council June 9, 1949 further described the Public Relations Committee functions as follows:

1. "Determine and write down general policies and objectives;
2. "Authorize headquarters staff to execute these policies, giving sufficient detail as regards scope and limitations of authority dele-

1959 ANNUAL MEETING
National Press Coverage

gated to the staff to make possible practical execution of the job;

3. "Act as adviser on special situations when and if such situations arise."

Public relations in SAE is a do-it-yourself operation, to borrow a phrase from President Raymond. It is carried on largely by many of its members and its member groups through individual programs, focussing on special objectives and specific groups which the Society tries to influence.

When President Raymond visited the Lycoming Division in Williamsport (one of a score of such visits he has made) and met with the key executives there, he was performing a public relations function. His visit left a favorable impression with management on how the Society is helpful to engineers at Lycoming and to the company in its engineering operation.

When 1958 President Bill Creson visited with professors and students at the University of Oklahoma last fall (and he visited some 50 such schools), that was public relations of the highest order. He created a clearer understanding of how the Society supplements the job performed by educators at the colleges. He created a warm and friendly impression of what SAE is.

Chet Mines, Chairman of the SAE Aero Space Committee, and Carl Sadler, who is about to succeed him, recently visited with General Demler at the Pentagon and they performed a public relations function. This visit left key military personnel with a good understanding of how SAE standards and specifications help government buy more weapons per dollar. They made it possible for more military personnel to cooperate with the Society in its technical committee work.

When Arch Colwell, Chairman of the Finance Committee, raises better than $20,000 from steel companies to support the SAE Cooperative Engineering Program, he performs a public relations job in the finest sense of the phrase. Obviously, he has convinced top management in the steel industry of the worth of the Society's cooperative technical work.

When SAE staff members pay courtesy calls on executives in plants throughout the country to express the Society's appreciation for their support, another public relations accomplishment has been chalked up for the Society.

When Membership Committee Chairman Howard Dunn and his group tell the SAE story to a prospective member, they are doing a public relations job.

On the local scene, Sections and Groups are doing public relations work through their activities. For instance, the Milwaukee Section's Annual Seminar on Engine Design Know-How creates a favorable impression on potential members . . . as does Central Illinois' Earthmoving Industry Conference, the Aircraft Production Meeting and Air Conditioning Conference of Texas Section.

When SAE Standards such as those on vehicle headlamps and brake fluids serve as sound engineering bases for state regulations, the Society forges a stronger link with industry and government.

These are but a few *isolated* examples of how public relations is handled in SAE. These examples do show that public relations isn't master-minded by one group, but carried out every day by the officers, committees, and hundreds of Society members actively participating in Society work. They also point up the six groups which SAE aims at influencing favorably in its public relations effort. They are:

1. SAE Members

We want to impress members with the values from Society membership, accomplishments of SAE, and the prestige that comes from association in the Society.

2. Potential Members

SAE's future depends upon bringing in new men to the Society qualified to contribute to and benefit from the work of the Society.

3. Students

College students are our engineers of tomorrow and members of the future.

4. Educational Leaders

Acceptance and recognition of SAE by college teachers and administrators is an important way in which SAE can reach its potential members who are now students.

5. Industry Executives

Active participation from SAE members, the very life blood of the Society, depends largely on the encouragement and stimulation these engineers receive from their management to work in the Society. Financial support from top management is a key to the success of the SAE Cooperative Engineering Program.

6. Government Agencies

Military and civil branches of the government profit from both the exchange of information within the Society and the development of standards and specifications in the Society's Cooperative Engineering Program. It is important to make the ever-changing parade of government and military

personnel aware of the values that the government derives from SAE work as well as getting actual cooperation from technical people in government.

The Society also engages actively in the more routine activities normally associated with public relations. Much of what SAE produces public relation-wise does get reduced to ink on paper. We have some examples here of these results:

Publicity for a National Meeting is another case of SAE do-it-yourself philosophy. A publicity Chairman appointed by the General Chairman of a given National Meeting works closely with the local press made available to him. Tools for the job are daily releases produced at headquarters and the papers being presented at the meeting. Some of the resulting newspaper stories are shown at the top of the opposite page.

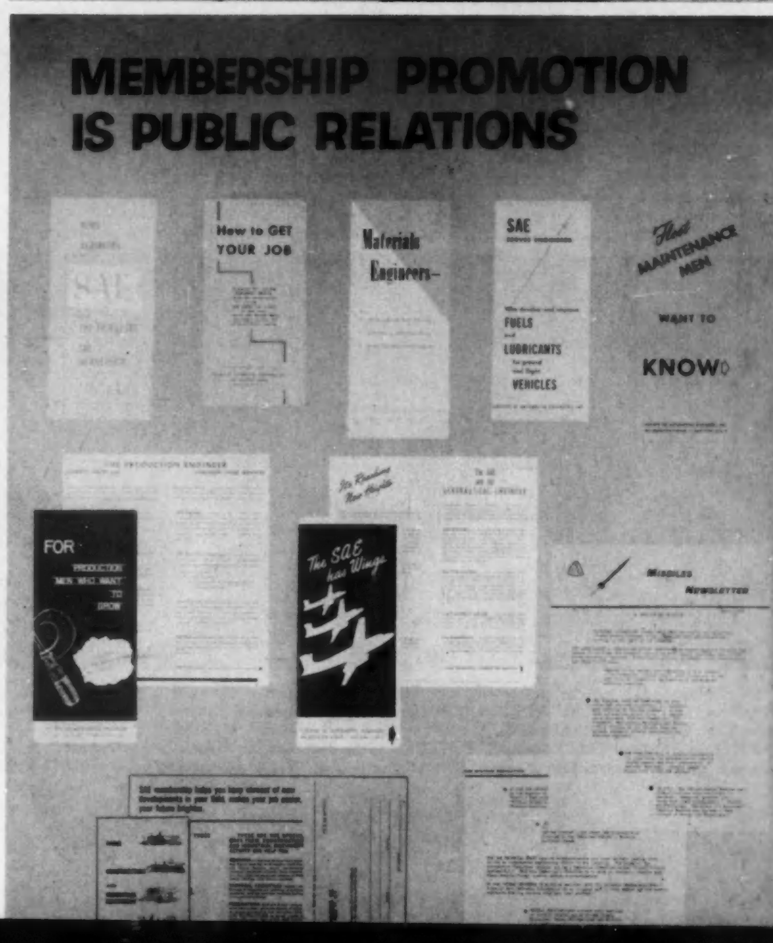
SAE cooperates fully with reporters and editors interested in getting special stories. A case in point is the article that was published in Automotive News on how an SAE paper is produced. You will recall it was reprinted in the Journal. Incidentally, we are told SAE relations with the press are exceptionally good. Newspaper reporters and magazine and trade paper editors have told us the Society is one of the most cooperative organizations with which they deal.

Promotional material printed by the Society is in effect a public relations tool. For instance, shown in the cut at the bottom of the opposite page is a brochure developed under Bill Creson's guidance for the education of educators on SAE. Shown in the same cut is a group of pamphlets developed for use by Arch Colwell and his group leaders who solicit top management in industry for support of SAE's Cooperative Engineering Program.

The Society's membership promotion program is in itself public relations. Some of the brochures aimed at engineers in various fields of automotive engineering are shown below. The most recent one, just off the press, is designed to tell the Society story for engineers in the farm and industrial machinery industries.

The three main ideas I want to emphasize are:

- First, that the Council-approved policies established in 1946 and reaffirmed again in 1953, are in keeping with SAE objectives and still make sense for us.
- Second, that these policies have been implemented and administered in accordance with changing needs as they arise.
- Third, that public relations in the SAE dictionary is performed daily by many hundreds of our members and scores of our committees and groups — as part of their specific SAE assignments and responsibilities.



1960 . . .

. . . Summer Meeting to Chi.

THE 1960 SAE SUMMER MEETING will go to the Edgewater Beach Hotel in Chicago. Present plans envision moving this meeting to different locations in following years. Projected at present are Washington, D.C., in 1961; St. Louis, Mo., in 1962; Montreal, Canada, in 1963; and back to Chicago in 1964.

S. J. Tompkins

The philosophy behind this recommendation of the Meetings Committee's Subcommittee on Summer Meeting Locations is to provide greater membership service to different parts of the country . . . and in hotels where the atmosphere is pleasant and relaxed.

Serving on the subcommittee under the chairmanship of S. J. Tompkins were F. P. Steiner, Anderson Ashburn, and Gregory Flynn, Jr.

OVERSEAS . . .

. . . and SAE.

THE COMMITTEE ON OVERSEAS UNITS—chairmanned by SAE Past-President W. Paul Eddy — agreed, following a review of past SAE Council actions, that:

1. Before giving any consideration to recognition of local units overseas, members in an area must have organized informally and have held technical meetings.

2. The organization must be generated by local members with such encouragement as firms in the area may provide.

3. The organization shall not compete with engineering societies or similar organizations of the country in which it is located.

In general, Chairman Eddy told SAE Council at its most recent meeting, the Committee is in harmony with a report approved by Council in September 1935, which recommended that:

> In countries where there is spontaneous interest in establishment of local units, the Society should encourage such activity to proceed along informal lines until such time as its size or importance would warrant further consideration.

TWO . . .

. . . new SAE Sections.

FORT WAYNE SECTION and ROCKFORD-BELOIT SECTION are new, official SAE agencies for expanding the Society's technical information services to local areas. Both were brought into being by action of SAE Council at its June meeting . . . when it also authorized extension of Williamsport Section's territory to include Clearfield County, Pa.

Fort Wayne

Fort Wayne Section has been functioning since 1952 as a Division of the Chicago Section. It moves to independent status with the encouragement and approval of both the Chicago and Indiana Sections.

Present Fort Wayne membership comes from 28 different companies and two colleges . . . and more than 87% of its 120 members hold either Member or Junior grade in the Society. The Section plans to continue to hold eight monthly meetings each year, and hopes to top its past 150 attendance record before the end of its first year as a full-fledged Section.

Regional vice-chairmen who have headed the Division since its inception have been H. B. Stone, Clark Equipment Co.; and E. S. Clifton, W. G. Armor, S. J. DiMilla, and E. J. Geiger of International Harvester; F. H. Schmidt of American Steel Dredge; and F. J. Michelbrink of Cleveland Graphite Bronze.

K. W. Finch
Chairman, 1959–1960
Fort Wayne Section

First chairman of the new Fort Wayne Section (for 1959–1960) will be K. W. Finch of Weatherhead Co.

Fort Wayne Section territory includes the following Indiana counties: Steuben, LaGrange, Noble, DeKalb, Whitley, Allen, Huntington, Wells, Adams, Jay, Blackford, Wabash, Miami, and Grant . . . and the following Ohio counties: Williams, Defiance, Paulding, Van Wert and Mercer.

Rockford-Beloit

The new Rockford-Beloit Section grew from a need for SAE services generated by the recent rapid industrial development in this tri-state area. The 50 to 150 miles to Chicago and Milwaukee Section meetings made an im-

MEN RESPONSIBLE for conducting the new Rockford-Beloit Group during its 1959–1960 inaugural year will include: Left to right: seated — E. J. Retzinger, Secretary; W. C. ARNOLD, CHAIRMAN; S. A. Malthaner, membership committee chairman; R. E. Miller, publicity committee chairman; J. H. Davids, vice-chairman for Diesel Engine Activity; and T. M. Robie . . . standing — H. F. Neuberger, publicity committeeman; J. L. Morgan, SAE Journal field editor; F. C. Skelton, vice-chairman for Truck & Bus Activity; R. A. Parker; J. B. Ingold, vice-chairman; and W. E. Johnson, program committee chairman. (Not pictured at this organizational meeting is J. R. Sturm, treasurer.)

portant phase of SAE activity almost unavailable to the 111 members already active. (Of the 111, some 90% are of Member or Junior grade.) And with an SAE membership potential of nearly 400 indicated by a recent survey, both Chicago and Milwaukee Section officers agreed readily with the local members that a separate section was indicated.

Represented in the territory of the new Rockford-Beloit Section are varied industries including aircraft, truck and bus, diesel engine, tractor, and farm machinery.

First chairman of the new Section (for 1959-1960) is Walter C. Arnold, (Fairbanks, Morse & Co.). Other officers are: J. B. Ingold, vice-chairman (Woodward Governor Co.); E. J. Retzinger, secretary (Fairbanks, Morse & Co.); Jay R. Sturm, treasurer (Sundstrand Aviation).

Territory of the Rockford-Beloit Section will include counties in both Illinois and Wisconsin . . . Walworth County, Wis. being split with the Milwaukee Section, and McHenry County Ill. being split with Chicago.

FISITA . . .

. . . Congress at Hague.

AN invitation to SAE from the Federation Internationale des Societes d'Ingénieurs des Techniques de l'Automobile to participate in its International Congress in The Hague May 8-13, 1960, is being referred to the six SAE Vice-Presidents in Activity areas most likely to be interested — Passenger Car; Body; Truck and Bus; Engineering Materials; Fuels and Lubricants; and Diesel Engine.

SAE's participation could take the form of one paper and an alternate from each of these Activities . . . SAE headquarters to act as coordinator, as desired.

The Congress lists its technical-area coverage as:

- Engines, including gas turbines, transmissions, lubrication and lubricants, combustion and fuels.
- Chassis, gearbox, suspension gears, brakes, safety.
- Body, equipment, aerodynamics, styling

JOB-WANTED

. . . listings scheduled next February for senior students.

CLASS OF '60 SAE ENROLLED STUDENTS will get a job-wanted listing in the February, 1960 issue of SAE Journal — without charge. Each

YOU'LL be interested to know . . .

SAE HAS A WAY OF POPPING UP . . . this time in Kansas City's Linda Hall Library, where a visiting staff member found a complete set of SAE Standards and Recommended Practices, and ground vehicle and aeronautic information reports. He found, too, that SAE Kansas City Section meetings are listed regularly in the Library's schedule of meeting activities.

Located in its own building at 5109 Cherry Street, the Library is free and open to the public. Designed especially (under the will of Herbert F. Hall in memory of his wife Linda) to provide information in the fields of science and technology — their application to natural resources, products, people, and problems of the region — it furnishes Kansas City with services not presently available in any other library.

W. F. BALLHAUS, of Northrop's Nortronics Div., has been appointed SAE's representative on the Daniel Guggenheim Medal Board of Award to serve for three years, starting Oct. 1. SAE's other representatives on the Board are J. B. Wassall and Jerome Lederer, whose terms expire Sept. 30, 1960 and 1961, respectively.

R. P. TROWBRIDGE (left), GM's director of engineering standards, will serve a four-year term as SAE's representative on the Elmer A. Sperry Board of Award, starting January 1, 1960.

DR. MICHAEL FERENCE (right), Ford's Scientific Laboratories director, is now SAE's representative on National Research Council's Division of Engineering and Industrial Research. His three-year term started July 1, 1959.

SAE'S SCIENCE-ENGINEERING COMMITTEE has seven new members. Council recently approved appointment of D. W. Heister, U. S. Army Ordnance Corps; A. W. Lawson, Institute for the Study of Metals; C. R. Lewis, Chrysler's Basic Sciences Laboratories; D. H. Loughridge, GM's Nuclear Power Engineering Research Laboratories; R. V. Pound, Harvard's Dept. of Physics; Harner Selvidge, Bendix Aviation; M. J. Zucrow, Purdue's Gas Turbines & Jet Propulsion Dept.

SECTION MEETING NOTICES are the heaviest item of operating expense for most Sections . . . And the per member cost of announcements rises sharply for the smaller Sections. This is but one outcome of a study in process by the Subcommittee on Section Finance — chairmanned by G. J. Liddell — which was set up by the Sections Executive Committee to assist Sections and Groups in their financial operations.

GUEST OF SAE JOURNAL for a 3-day orientation last month on how technical magazines are edited in United States was Ram D. Taneja from New Delhi, India. Taneja is on his way back to India following attainment of a Master of Science degree in technical writing in Rensselaer Polytechnic Institute, where he has been studying for the past year.

He is associate editor of Research & Industry, published by the Council of Scientific and Industrial Research — an Indian governmental agency concerned with organization and management of scientific and industrial research in India.

AIRCRAFT POWERPLANT ACTIVITY COMMITTEE'S newest member is R. G. Laucher, Marquardt Corp. . . . And **VERNE T. KOPPIN** of Creative Industries has recently been appointed to the **BODY ACTIVITY COMMITTEE.**

G. WALKER GILMER, Arabian American Oil Co., and SAE Vice-President for Air Transport Activity, will represent the Society at Cooper Union's Academic Convocation on Nov. 2-3. The Convocation commemorates the 100th anniversary of the formal opening of Cooper Union.

about-to-graduate enrolled student will receive a form from the SAE Placement Service before the end of 1959, together with an invitation to fill in his name, his after-June address, the job he wants, and where he would like it to be located.

The published listing — in addition to reaching the more than 28,000 SAE Journal engineer and management readers — will be brought especially to the attention of some 800 companies with whom SAE Placement Service is in regular contact.

Stimulus for publication of such a list came from E. P. White at a Placement Committee meeting last January. Then Placement Chairman of the Pittsburgh Section, White is now SAE Student Committee chairman.

FACTS

. . . from SAE literature.

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.)

OVER 3,000,000 copies of SAE Aeronautical Materials Specifications are in use by industry and military air services throughout the world. SAE Technical Committees issue more than 100 new or revised specifications annually . . . from "Materials Engineers" — an SAE Membership Committee pamphlet.

EVERY NEW ENGINE creates a new challenge . . . to move it needs fuel, it rides on a lubricant film . . . and SAE is the communication channel between automotive and petroleum engineers. From "SAE Serves Fuels and Lubricants Engineers," developed for the SAE Membership Committee.

OTHER PAMPHLETS recently developed for the Membership Committee are "Fleet Maintenance Men Want to Know" and "Farm, Construction, and Industrial Machinery Engineers."

$1,500,000 IS THE ESTIMATED VALUE of manpower and laboratory facilities being drawn upon in a single year by Coordinating Research Council, according to CRC's new booklet "The Story of the Coordinating Research Council." Of this value, 50% is attributed to the petroleum industry; 35% to the equipment industry; 10% to chemical companies; and 5% to Government agencies, research associations, universities, etc.

The booklet tells of CRC's structure, how it is financed, what it has accomplished, its plans for continued cooperative research — and emphasizes its "motif" that the chief benefit of cooperation is cooperation itself. CRC is sustained jointly by the SAE and the American Petroleum Institute.

SAE NATIONAL MEETINGS

- **September 14–17**

  National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 5–10**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 26–28**

  National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- **October 27–29**

  National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- **October 28–30**

  National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

AUDIT . . .

. . . of Journal Readers.

SAE JOURNAL'S June issue was officially audited by Business Paper Audit of Circulation (BPA) . . . and from now on will be supplying its potential advertisers regularly with up-to-date officially authenticated information about its readers . . . how many there are, what sort of plants they work in, what sort of work they do. Tabulations resulting from this audit will be ready by Sept. 1.

Most of this vitally necessary information is tabulated from the TWO checkmarks which SAE members now make on the following classification form attached to their bills:

THANKS for your dues payment. However, we must have your **TWO** checkmarks — ***ONE IN EACH COLUMN.*** On the left, check the number which comes closest to describing the industry in which you work. On the right, the letter which comes closest to the work you do personally.

INDUSTRY	OCCUPATION
☐ 1. Complete Vehicle Mfrs. (ground & air)	☐ A. Corporate Officials
☐ 2. Parts & Equipment (for ground & air)	☐ B. Mfg. & Operations Executives
☐ 3. Engine Mfrs. (ground & air)	☐ C. Mfg. & Production Engineers
☐ 4. Materials Producers & Suppliers	☐ D. Engineering Executives
☐ 5. Production Equip. Mfrs. (for ground & air)	☐ E. Design, Development & Industrial Engineers
☐ 6. Transp. & Maintenance (ground & air)	☐ F. Research Engineers
☐ 7. Professional Engrg. Services (including Consulting Engineers)	☐ G. Vehicle Operation & Maintenance Engineers
☐ 8. Petroleum & Chemicals	☐ H. Sales Engineers
☐ 9. All Govts. (including Military)	☐ J. Educators, Librarians, Editors & Advertising Executives
☐ 10. Educational, Editorial & Other Communications	
☐ 11. ______	☐ K. ______

SAE TECHNICAL COMMITTEES

TRANSPORTATION AND MAINTENANCE SUBCOMMITTEES

FLEET OPERATORS will be interested to learn of progress being made by two subcommittees of the Transportation and Maintenance Technical Committee.

An improved and completely revised edition of the SAE Maintenance of Automotive Engine Cooling Systems Manual will be available after the first of the year, according to F. A. Gundlach (left), chairman of the Cooling System Maintenance Subcommittee.

A listing of instruments for preventive maintenance inspections . . . how they are used and what for . . . forms the basis of a new SAE report destined for inclusion in the SAE Handbook, reports A. W. Neumann (second from left), chairman of the Instruments for Preventive Maintenance Subcommittee.

Also shown at a recent TMTC meeting are G. H. Maxwell and Dale Robertson (far right).

PUSH, PULL, TRIP OR FLIP? That's what the new Tractor Protective Valve Subcommittee tried to decide at its first meeting held in Atlantic City during Summer Meeting. The group's official assignment is to investigate the possibility of standardizing the operation of tractor protection valve controls. From left are: Robert Gardner, Regular Common Carrier Conference; C. P. Hoffmann, Jr., American Trucking Assns.; Chairman W. T. Johnson, Los Angeles Dept. of Water and Power; and Roy Herring, Sealco Air Brakes.

Killed Steel Does Age!

IF you want to know how aging affects the selection and useage of carbon and strip steels, you'll be interested in what members of a new ISTC subcommittee of Division 32, Carbon Sheet and Strip Steel, are doing. . . . They're contemplating the possibility of creating a new SAE Information Report which would give non-metallurgists practical information on carbon and strip steels. In addition, they're trying to correct the misconception that killed steel does not age.

So says Subcommittee Chairman W. O. Manuel of GMC's AC Spark Plug Division.

How to Git And Stay Hitched

IF your goal is to provide farmers with reliable hitches for implements attached to the back of wheeled tractors, a look at a new SAE Standard will help you attain it. The document contains specifications for attaching three-point hitch implements and equipment to agricultural wheeled tractors by means of a three-point free-link hitch.

Included are standard dimensions for mast height, mast pitch adjustment and implement leveling adjustment. Location of link attachment points is not restricted.

Specifications are divided into two categories. Both cover hitch dimensions intended for tractors having drawbar pulls based on SAE-ASAE Agricultural Tractor Test Code — Test H.

Category I — covers tractors having a work capacity up to 2500 lb. drawbar pull.

Category II — covers tractors having a work capacity over 2500 lb. drawbar pull.

Titled Three-Point Free-Link Hitch Attachment of Implements to Agricultural Wheeled Tractors, this Standard was developed by SAE in cooperation with the Advisory Engineering Committee of the Farm Equipment Institute. It has been approved by the SAE Technical Board for inclusion in the 1960 SAE Handbook.

This is the first . . .

. . . of four stories on the newly formed Councils of the SAE Technical Board. The Board's recent reorganization is described in full on pages 106 and 107 of the July issue.

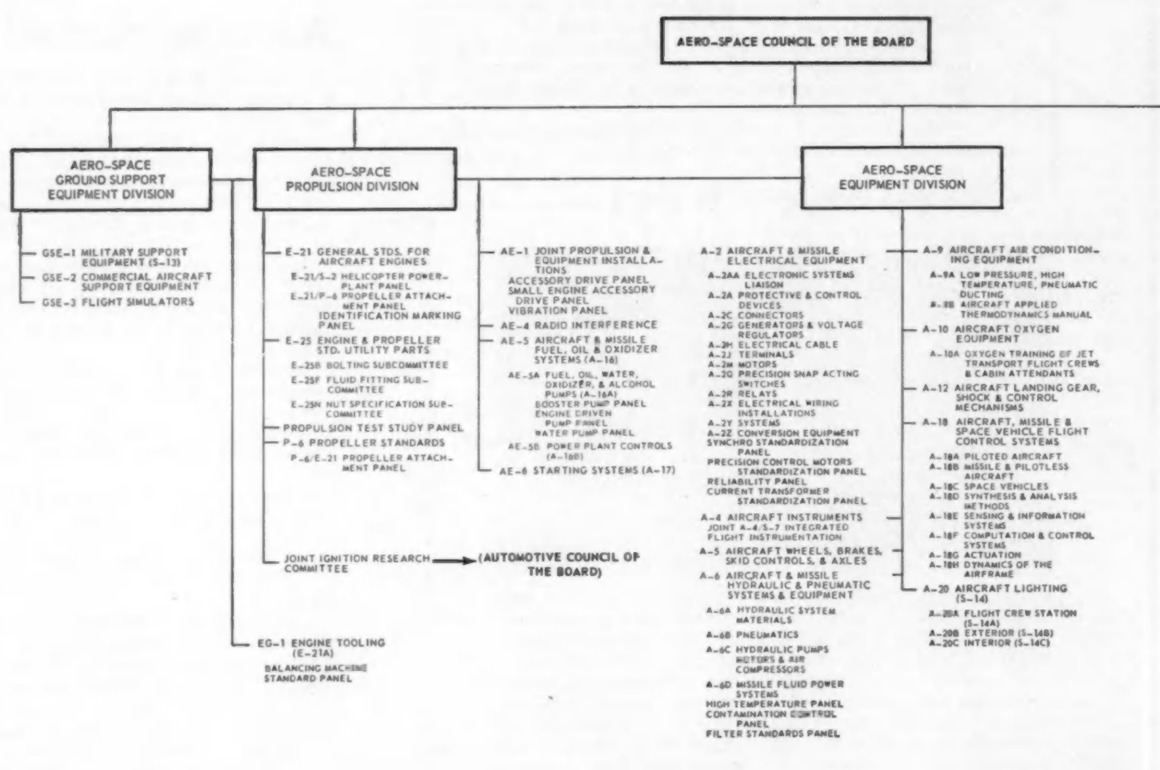
Introducing the

Aero-Space Council

THE thirteen distinguished aeronautical engineers who have joined Chairman **Carl L. Sadler**, president, Sundstrand Aviation Division, as members of the newly formed Aero-Space Council of the SAE Technical Board are: **R. D. Kelly**, superintendent of the Technical Development Division, United Air Lines; **J. H. Famme**, works manager, Plant 2, Convair Division, General Dynamics; **P. H. Jones**, section head, propulsion systems installations, North American Aviation; **R. R. La Motte**, manager of engineering, Aeroproducts Operations, Allison Division, GMC; **W. C. Lawrence**, assistant vice president, engineering, American Airlines; **W. G. Lundquist**, technical consultant, Reaction Motors Division, Thiokol Chemical Corp.; **D. M. McGrath**, plant manager, Solar Aircraft Corp.; **C. E. Mines**, chief, engineering services, Allison Division, GMC; Dr. **Arthur Nutt**, consultant, Lycoming Division, AVCO; **N. E. Promisel**, chief material scientist, Bureau of Aeronautics, Navy Dept.; **John Wallen**, head, Production Projects Department, Utah Division, Thiokol Chemical Corp.; and **E. C. Wells**, vice president and general manager, Systems Management Office, Boeing Airplane Co.

To coordinate the Aero-Space Council's work with the accomplishments of the former Aero-Space Committee, the nucleus of its membership was drawn from the previously existing Technical Board group. Since the Board's reorganization, committees formerly under Aero-Space Committee jurisdiction have been reassigned to one of six Aero-Space Council divisions. As indicated below, the Council divisions govern technical committee work in the following area: Ground support

SAE AERO-SPACE COUNCIL ORGANIZATION



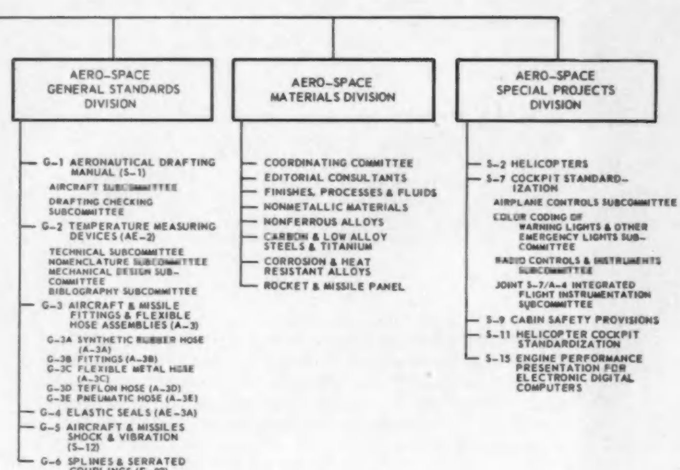
of the Technical Board

equipment, propulsion, equipment, general standards materials, and special projects.

What They Will Do

Each year, members of the Aero-Space Council will review approximately 200 SAE technical documents (AMSs, ASs, ARPs, and AIRs) emanating from some 40 main committees. (Approximately 300 recommendations will be forwarded to the Military Services directly from groups under the Council.) These reports range in content from performance specifications for equipment and systems to standard part drawings and material specifications. They will be used on a voluntary basis by both the aircraft and missile industries as well as by the Military Services.

The 900 engineers now serving as members of SAE aeronautical technical committees are only one measure of industry interest in the work of the Aero-Space Council. In addition to actual committee membership, some 400 engineers attend committee meetings each year. Last year, this engineering force, combined with the cooperative engineering needs of the aviation industry, produced the following documents.



Chairman Sadler

Extending the Life of Hydraulic Pumps

Service life of hydraulic pumps used in aircraft and missiles has long been a problem to members of SAE Subcommittee A-6C, Hydraulic Pumps, Motors, and Air Compressors. Optimum cleanliness in hydraulic circuits being their aim, members set up standard procedures for obtaining filter patch test samples from engine mounted pumps and auxiliary power driven pumps. These recommendations are contained in ARP 575, Procedure and Method Evaluation of Filter Patch Testing for Aircraft Hydraulic Pumps.

Performance Data and High-Speed Digital Computers

At the request of the Aero-Space Industries Association, a recommended practice for presenting engine performance data in the form of punched cards or magnetic tape for use on high-speed digital computers was developed by the new Committee S-15, Computers. The resulting document (ARP 681, Engine Performance Presentation for Use on High-Speed Digital Computers) eliminates programming and preparation of data for analysis by airframe manufacturers computing installed engine performance.

Prevention and Control of Autogenous Spark Ignition

Design factors affecting the ability of a pump motor or pump housing to act as an autogenous or spark ignition source for explosive fuel vapors within a fuel tank are the subject of ARP 594, Fuel Booster Pump Design Provisions for Autogenous and Spark Ignition Prevention and Control. Many months of investigation were required before members of Subcommittee AE-5A

Fuel, Oil, Water, Oxidizer and Alcohol Pumps, were able to complete their recommendations.

Refueling Hoses

The first document to clear the Aero-Space Council was ARP 605, Routine Inspection and Test Procedures for Aircraft Refueling Hoses. This report specifies minimum inspection requirements and test procedures for aircraft refueling hoses. These hoses are ground equipment types normally used for ground refueling of aircraft from storage tanks, mobile tanks, or tank trucks. ARP 605 was prepared by Subcommittee G-3A, Synthetic Rubber Hose.

Testing High-Temp, High-Pressure Hose Assemblies?

Soon to be issued are recommended tests for high-temperature (400 F) high-pressure (3000 psi) hose assemblies used in aircraft and missiles. These tests include (among other things) tests for leakage, burst, thermal shock, and overtightening torque. Prepared by Subcommittee G-3D, Teflon Hose, the report is known as ARP 604, Hose Assemblies: Aircraft and Missiles, High Temperature, High Pressure.

Selecting Turbine and Compressor Rotor Blades

Selecting turbine and compressor rotor blades can be simplified by use of information contained in ARP 510, Moment Weight of Turbine and Compressor Rotor Blades. This report specifies two methods (direct and code) of marking the moment weight directly on turbine and compressor rotor blades for classification purposes. Use of the methods permits direct blade selection when balancing of rotating assemblies (within acceptable limits) is required during initial engine build-up and maintenance operations. ARP 510 was prepared by Committee E-21, General Standards for Aircraft Engines.

Locking Devices

Requirements for the safe and reliable locking of various fasteners and other parts used on aircraft powerplants have been set up by Committee E-21, General Standards for Aircraft Engines. The document is known as AS 567, General Practices for Use of Lock Wire, Key Washers, and Cotter Pins.

Automatic Pilots

Last winter Committee A-4, Aircraft Instruments, revised AS 402 (Automatic Pilots) extensively. The resulting document, AS 402A, contains minimum performance requirements for automatic pilots on civil transports having reciprocating engines. The committee is now working on environmental requirements for turbine powered aircraft which will be issued as AS

Continued on next page.

In Command of the

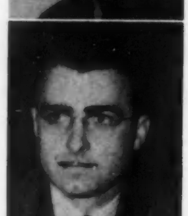
Aero-Space Council Chairman **CARL L. SADLER** is a former Technical Board and Aero-Space Committee member. From 1952 until the Board reorganization, he was chairman of the Committee's Accessory and Equipment Division. Sadler's prime industry concern is being president of the Sundstrand Aviation Division.

Vice chairman of the Aero-Space Council is **RAYMOND D. KELLY,** superintendent, Technical Development Division, United Air Lines. A former Vice President for both the Aircraft and Air Transport Activities, he has been appointed chairman of the Council's Ground Support Equipment Division.

As **J. H. FAMME** joins the Aero-Space Council, he is a member of the SAE Council and the SAE Missiles Advisory Committee. A former Vice President for Aircraft Activity, he is now a member of that group. At Convair where he is assistant chief engineer, Famme directed the engineering of the delta-wing supersonic intercepters of the F-102 and F-106 series.

Prior to becoming chairman of the Aero-Space Council's Equipment Division, **P. H. JONES** organized the first SAE technical committee on aircraft fuel systems and equipment (AE-5) and served as chairman of that group from 1953. At North American Aviation, Jones is section head for systems installations.

R. R. LA MOTTE has been chairman of both the Aircraft Propeller Division (existing under the Aero-Space Committee) and the Dayton Section. He has also served on the Powerplant Activity Committee. At Aeroproducts Operations, GMC's Allison Division, he is manager of engineering.



The 1957 SAE Vice President for Air Transport, **W. C. LAWRENCE** was chairman of both the Aero-Space Committee and, for many years, the Committee's Accessory and Equipment Division. He has also served on the Technical Board. Currently, Lawrence is assistant vice president, engineering, American Airlines.

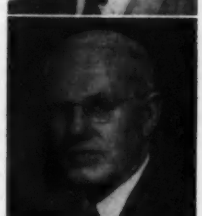
Chairman of the Aero-Space Council's Propulsion Division is **W. G. LUNDQUIST**, technical consultant, Reaction Motors Division, Thiokol Chemical Corp. A former Aero-Space Committee member, he was chairman of its Propulsion Division.

Aero-Space Council

D. M. McGRATH's membership on Committee A-2, Aircraft and Missile Electrical Equipment, began in 1940 and ended 11 years later when he joined the Aero-Space Committee. During his membership in the latter, McGrath was the group's liaison with the Aero-Space Industries Association's Aircraft Equipment Technical Committee.

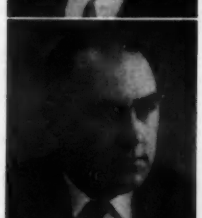
The chairman of the 1959 SAE New York Aeronautic Meeting, **R. W. MIDDLEWOOD** joins the Aero-Space Council after having served on both the Aircraft and Air Transport Activity Committees. A former Aero-Sapce Committee member, Middlewood is manager of Lockheed Nuclear Products. While chief engineer of Lockheed's Georgia Division, he directed production engineering development of the C-130 Hercules.

C. E. MINES, who is chief of Engineering Services at GMC's Allison Division, was 1958 SAE Vice President for the Aircraft Powerplant Activity. A former member of the Technical Board, he was chairman of the Aero-Space Committee from 1954 until the Board reorganization. Mines is currently a member of the Aircraft Power-plant Activity Committee.



Past SAE President **ARTHUR NUTT** is one of the original members of the Technical Board which was formed in 1945. A Councilor in 1944, he is now a member of the Board of Directors of the Coordinating Research Council. Dr. Nutt, who is a consultant at AVCO's Lycoming Division, is chairman of the Aero-Space Council's General Standards and Special Projects Divisions.

Chairman of the Council's Aeronautical Materials Specifications Division is **N. E. PROMISEL,** chief material scientist, Bureau of Aeronautics, Navy Department. For many years a participant in AMS work, he is well known for his efforts to coordinate government sponsored metallurgical research and development.



JOHN E. WALLEN comes to the Aero-Space Council after having served on the Aero-Space Committee. As head of the Production Projects Department of Thiokol Chemical Corp.'s Utah Division, he is responsible for all production projects. Prior to his present assignment, Wallen directed the development of the solid-propellant first stage of the Minuteman ICBM.

E. C. WELLS is currently a member of the Technical Board. He has served on the Aircraft Activity Committee and has been an SAE member since 1943. At Boeing Airplane Co., Wells is vice president and general manager of the Systems Management Office.

440, Automatic Pilots—Turbine Powered Aircraft, at some future date.

Drafting Practices

Established drafting practices for showing various common part elements are given in ARP 591, Conventional Representation. They reflect a compromise between complete pictorial representation and complete symbolization. Prepared by Committee G-1, Aero-Space Drafting Manual, ARP 591 was designed to cut down drafting time as well as promote greater clarity.

Silver and Copper Brazed Joints

Pertinent data on the design of silver and copper alloy brazed joints used throughout the aircraft powerplant industry are contained in ARP 573, Silver and Copper Alloy Brazed Joints for Aircraft Powerplants. Design configurations, engine and propeller standard utility parts, and other powerplant components are covered. Developed by Committee E-21, General Standards for Aircraft Engines, the report also provides standard practices for the design of swaged tubing and of inside diameters for mating parts of fittings for silver or copper brazed joints.

Powerplant Fire Detection

Minimum requirements for powerplant fire detection instruments for use in turbine powered civil transports are given in AS 430, Powerplant Fire Detection Instruments — Turbine. This Aeronautical Standard covered four basic types of fire detection instruments used to protect powerplant installations where fuel, oil, or similar fires may occur. AS 430 is the work of Committee A-4, Aircraft Instruments.

Cabin Pressurization

Recently revised was ARP 367, Airplane Cabin Pressurization. This document provides recommendations which cover: General requirements for pressurized airplanes, cabin air compressors, cabin pressure regulating equipment, engine bleed air duct systems, and cabin pressure ducting system.

What's It Made Of?

The prime objective of the AMS Division of the Aero-Space Council is to develop quality materials specifications for use by the aircraft, missile, engine, and parts and accessories industries. Since last August, 38 new and 70 revised AMSs have been issued by the Society.

The 330 engineers currently developing AMSs represent a cross-section of materials experts. Since 1940 when the first specification was issued, well over ten and a half million AMSs have been sold by SAE.

Only a Thumb-Nail Sketch

The foregoing is only a thumb-nail sketch of what happens in SAE aeronautical technical committees and is meant to give SAE members an idea of the extent of Aero-Space Council work.

Jet Oxygen Equipment

Continuing A-10 Study

By

Arthur E. Miller

Chairman of SAE Committee A-10, Aircraft Oxygen Equipment

OXYGEN EQUIPMENT now in use on all jet transports (except Russian) embodies the best current solutions to the difficult problem of supplying passengers with oxygen under emergency conditions.

Resulting largely from suggestions developed by SAE Committee A-10 on Aircraft Oxygen Equipment, the currently applied equipment makes oxygen masks available to every passenger within seconds after decompression . . . and unless the passenger is already unconscious, he can grasp the mask and place it on his face in another few seconds. Should he be unconscious, his companion or seat partner can, after securing his own mask, place his companion's mask on his face for him.

In the Boeing 707, Convair 880, Comet IV, Bristol Britannia, and Sud Caravelle, the oxygen masks are concealed in compartments located above each seat-row. Should the cabin lose pressure, an automatic barometric pressure-sensing control opens all the compartments simultaneously and drops the oxygen masks to where they can be seen and reached by the passengers. Oxygen is not delivered to the mask until the passenger pulls the mask to his face thus tripping a valve — which allows the oxygen to flow to the mask. The masks are round, symmetrical cups. There is no right side up or wrong side up. As long as the mask is placed on the face, regardless of orientation, a proper fit is achieved.

In the Douglas DC-8, the system is basically the same except that the masks instead of being located in overhead compartments are located in a compartment in the seat-back. In the event of decompression, the compartment in the seat-back pops open, exposing to the passengers behind that seat the oxygen masks, which they need only to grasp and pull up to their faces. The pulling of the mask from the compartment trips the oxygen valve to allow oxygen to flow to the mask.

Any of these systems is much more expensive to install than the oxygen systems in the old piston engine airplanes, and it took many years of discussion, argument and development, as well as mutual cooperation between all parties, companies, government agencies, and others concerned, before the final designs were achieved and put into practice.

Before arriving at these currently practical methods, SAE Committee A-10 (and its predecessor the Subcommittee on Oxygen Equipment of Committee A-9, Aircraft Air Conditioning Equipment), examined and discussed scores of varied suggestions for nearly seven years. Included in the Committee's membership and in its discussions were the viewpoints of experts from the leading airplane manufacturers, airlines, oxygen equipment manufacturers, the Air Force, and the Bureau of Aeronautics. Consulted also were independent doctors and physiologists.

Possible Solutions

Every possible type of solution was explored — even though some, in retrospect at least, seem little short of humorous. Some of the solutions considered, for example, were:

(1) Flooding the entire cabin with oxygen, either from high pressure cylinders or from liquid oxygen converters. This notion was abandoned because of the bulk and the weight of the oxygen containers which would be required to supply the tremendous volume of oxygen needed, as well as because of the fire hazard in flooding the cabin with a high concentration of oxygen in the presence of combustible materials and lighted cigarettes.

(2) Plastic domes or bell jars which would drop down from the ceiling over each passenger's head, and to which oxygen would be delivered through the hose from which the jar was suspended. This idea was abandoned because of the impracticability of assuring that each jar would land squarely over its target rather than on it, and the danger of surrounding a smoking passenger's head with a high concentration of oxygen.

(3) Plastic bags which would be dropped from overhead above each passenger, which the passenger would pull down over his head and tie around his neck. Oxygen would be delivered to the plastic bag through the rubber tube by which it was suspended. Experiments with such a device proved that it would not be practical, especially with women wearing fancy hats or hairdos. Also, there was the fire hazard if the passenger should pull the bag over his head while smoking.

(4) A mechanical hand which would be built into the seat-back and which in the event of decompression would reach around and place an oxygen mask on the passenger's face. This too was discarded as impractical because of the difficulty in assuring that the hand would find the face, and place the mask thereon properly, in spite of the differences in sexes and physiques of passengers, ranging from children to adults.

(5) Fitting each passenger with a modified form of the military pressure suit which consists of a suit encasing the entire body, with a helmet enclosing the head. In the event of decompression, the suit would automatically be filled with oxygen. This was discarded as an impractical solution because of the problems involved in measuring and fitting of all of the passengers (especially the female sex) before boarding the airplane.

These were but a few of the solutions proposed. There were others — but none could be made sufficiently practical to permit immediate application. The solution currently in use was achieved by Committee A-10's correlating the necessary information and meeting the desires and views of all the interested parties.

Committee A-10 is now carrying its studies further. It is seeking means to update and refine existing oxygen equipment standards, and is exploring even newer and more sophisticated systems for possible future use in civil transport aircraft.

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Members of A-10 include: Chairman Arthur E. Miller, Scott Aviation Corp.; William Bird, Trans-Canada Air Lines; W. V. Blockley, North American Aviation, Inc.; F/L A. Charles Bryan, Department of National Defense, RCAF; Richard Coulter, United Airlines, Inc.; T. Cook, Lockheed Aircraft Corp.; W. Dray, Pioneer Central Division, Bendix Aviation Corp.; E. G. Erickson, Capital Airlines, Inc.; Carl Jonasson, Boeing Airplane Co.; Frank Hale, U. C. L. A.; Gordon Little, Canadair Ltd.; A. S. Lucking, British Overseas Airways Corp.; R. Maddock, Douglas Aircraft Co.; S/L E. G. D. Maynard, RCAF, Institute of Aviation Medicine; Lynn McDonald, Grumman Aircraft Engrg. Co.; G. F. Moore, Convair Division; Clyde Morsey, American Airlines, Inc.; J. Poppen, M. D., Office of Naval Research; A. H. Schwichtenberg, M. D., Lovelace Clinic; R. T. Stringer, Firewel Co., Inc.; T. F. Tesmer, Linde Co.; A. Tidd, Rose Aviation, Inc.; W. H. Trammell, Lockheed Aircraft Corp.; E. Witek, Convair Division. Liaison representatives include: D. R. Good, Wright Air Development Center; Dr. J. N. Waggoner, United Air Lines, Inc.; Consultants include: Dr. W. R. Lovelace, II, Lovelace Clinic; R. A. McFarland, Ph. D., Harvard University, School of Public Health.

SAE SECTIONS

THE ENGINEERING STUDENT, his profession, and the SAE was the theme of WESTERN MICHIGAN SECTION'S May 5 meeting. Dr. Louis L. Otto, Michigan State University's mechanical engineering professor, was main speaker. SAE Student Contest Awards were presented for the winning papers: "The Turboprop Engine" by William A. Spencer, and "The Pulse-Jet Engine" by Willard Greene — of Muskegon College; "Quantum Mechanics — Development of Its Principles to Explain Atomic Phenomena" by Suzanne Gooder, and "Vanguard, Its Design and Detail" by Thomas Hoogerhyde — of Aquinas College; "Guided Missiles" by Keith Nyenhuis, and the "Free Piston Engine" by Jason Alofs of Calvin College; "The X-15" by Ray Boven, and "Desmodromic Valve Actuation and Its Application to Automotive Engines" by Richard Boulard of Grand Rapids Junior College.

There was a good turnout of 58–59 Section officers at Western Michigan Section's May 5 meeting, as shown (left to right) Herman F. Stapel, Section Chairman; Calvin De Bruin, Student Activity Chairman — Muskegon; Louis L. Otto, main speaker; Harley Smith, Student Activity Chairman — Grand Rapids; Elias W. Scheibe, Section Vice-Chairman — Grand Rapids.

★

BEST ATTENDED MEETINGS last Section-year at PHILADELPHIA SECTION were the annual Student Meeting, which was devoted to the Indianapolis 500-Mile Race . . . and the one at which members toured the Mack Truck plant at Allentown. Attendance at both these gatherings topped 125 . . . while the other meetings averaged around 50 to 60.

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Over 150 NORTHERN CALIFORNIA SECTION members visited Hamilton Air Force Base on May 28 and heard 1st Lt. Bill Burke talk on the world's fastest fighting plane — the F-104. Here a portion of the group is hearing a description of the craft from one of the pilots. The stubby shape of the wing is apparent and the track for mounting a sidewinder missile is shown in the foreground.

A large percentage of NORTHWEST'S total membership attended the Section's dinner dance at the New Yorker Cafe in Tacoma, Wash., on May 15. Prominent among those present (left to right) 1958–59 Section Chairman L. M. Landwehr; Past-Chairman John Conti; Mrs. John Conti; Mrs. Otto Kirchner and 1959–60 Section Chairman Otto Kirchner.

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OUTBOARD MOTORS was the subject of two last-of-season Section's meetings.

After MID-MICHIGAN'S golf session on May 26, Scott-Atwater's L. E. Haas (above, left) spoke on performance characteristics of outboards . . . and McCulloch's L. W. Foster told NORTHERN CALIFORNIA'S South Bay Division on June 2 that bigger and better outboards (100 hp or more) can be expected. (Left to right) Speaker Foster and W. H. Moranda, technical chairman of the meeting.

INDIANA SECTION heard Peter DePaolo, famed racing driver, speak on highlights of Indianapolis races of the past, at its Annual Race Meeting and Ladies Night on May 20. At speakers table (left to right) Peter DePaolo; W. M. Horner, retiring Section chairman; Henry Banks, director of competition, USAC; Sam Hanks, 500-mile race director and 1957 winning driver; M. E. Estey, incoming Section chairman.

81 MEMBERS and guests attended SAE WILLIAMSPORT GROUP'S Ladies Night meeting on May 28. Here (left to right) are the C. W. Bishops (honor guests), the J. H. Carpenters (he's the retiring Section chairman); the Paul Cervinskys (he's a past chairman); and the J. H. Lavos (he's the incoming Section chairman).

SAE MEMBERS

T. R. THOREN has been made vice-president, engineering, of Pesco Products Division, Borg Warner Corp. Previously Thoren was assistant to the vice-president and general manager, Ramo-Wooldridge Division, Thompson Ramo Wooldridge, Inc. Thoren is 1959–1960 SAE councilor and was 1958 chairman of the SAE Sections Committee.

DELMAR D. ROBERTSON has been appointed vice-president in charge of automotive engineering with the Budd Co. in Detroit. Until recently, he was vice-president, sales with Dana Corp. Some years ago, Robertson was chief engineer of Wilkening Mfg. Co., following four years as a steel erection engineer with Bethlehem Steel Co. He is a graduate of Georgia Institute of Technology and did graduate work at the University of Pennsylvania.

F. EUGENE NEWBOLD, Jr. has become vice-president, engineering and marketing of Fairchild Engine & Airplane Corp. Formerly he was vice-president and general manager of Fairchild Engine Division.


Thoren


Robertson


Newbold


Falvey

JAMES P. FALVEY has been made chairman of the board, Electric Auto-Lite Co. Falvey has been president of Auto-Lite for the past five years.

ROBERT H. DAVIS has become president and a director of Electric Auto-Lite Co. Previously he was associated with Clark Equipment Co., as vice-president.

EDWIN R. STROH has been appointed to the newly created post of vice-president and director of sales for the Electric Auto-Lite Co. Previously he was vice-president and automotive sales manager for Holley Carburetor Co.

Past SAE Councilor **CHARLES A. CHAYNE**, past SAE President **JAMES C. ZEDER**, and **ANDREW A. KUCHER** have been elected members of the Board of Directors of the University of Michigan Development Council. Chayne is vice-president, engineering staff, General Motors Corp. Zeder is vice-president, Engineering Division, Chrysler Corp., and Kucher is vice-president, Ford Motor Co.

JOHN E. MITCHELL has become general sales manager of Industrial Truck Division, Clark Equipment Co. Mitchell came to Clark in 1957 as general manager of the New York City factory branch.

PETER M. SARLES has been appointed manager of materials control at Aviation Gas Turbine Division, Westinghouse Electric Corp. He was previously staff assistant to the division manufacturing manager.


Davis


Stroh

AIR COMMODORE F. R. BANKS (ret'd), at his own request and for personal reasons, has relinquished the post of sales director of Bristol Siddeley Engines, Ltd., Bristol, England. He has also retired from the Board of the Company. He is now located in London at 5a, Albert Court, Knightsbridge, S.W. 7.

GEORGE R. SQUIBB, formerly chief project engineer of Process Developing Section, General Motors Corp., has been made president of Automotive Conversion Corp. After spending 15 years on the staff of Cincinnati Milling Machine Co., Squibb became chief engineer for Detroit Broach Co. Later he joined the staff of General Motors Corp.

TULLIO TOGNOLA has been named an assistant director of engineering with Bendix Aviation Corp. Previously he served as chief research engineer.

RALPH L. BAYLESS, formerly chief engineer of Convair Division, General Dynamics Corp., has been appointed director of engineering, Convair Division.

R. K. McCONKEY has become general manager of Industrial Division, Timken Roller Bearing Co. Previously he was assistant general manager of Industrial Division.
WYN E. McCOY succeeds McConkey as assistant general manager of Industrial Division, Timken Roller Bearing Co. His previous position was sales promotion manager.
S. C. PARTRIDGE, formerly general manager, Industrial Division, has been made director of sales, International Divisions, for Timken Roller Bearing Co.

JAMES A. TAYLOR, former vice-president of Standard Screw Co., has been elected president of the company. Taylor will continue to serve as president of Hartford Machine Screw Co., a division of Standard Screw.
W. D. CORLETT, former president of Standard Screw Co., advances to chairman of the board. He is also president of the Chicago Screw Co., a division of Standard Screw.

ANDREW B. PULLIAM has been appointed president and general manager of Marvel-Schebler Products Division, Borg-Warner Corp. Pulliam joined Borg-Warner in 1956 as director of manufacturing services. Prior to his recent appointment, he was vice-president and general manager of Marvel-Schebler.

R. C. INGERSOLL, chairman of the Board, Borg-Warner Corp., has relinquished his duties as president and general manager of Marvel-Schebler Products Division to devote more time to company-wide responsibilities.

W. D. REESE recently retired as manager of engineering, Motor Truck Division, International Harvester Co. Reese began his career during World War I with an armament company in the East (manufacturing guns). Subsequently he joined the Fifth Avenue Coach Co., Yellow Sleeve Valve Engine Works, and Yellow Truck and Coach Co. (which later became General Motors Corp. Truck and Coach). He joined International Harvester Co. in 1934 as assistant to chief engineer in charge of automotive engineering. Prior to becoming manager of engineering he served as assistant to vice-president in charge of engineering for Motor Truck Department.

GEORGE F. CHAPLINE has recently retired as vice-president of military requirements, Fairchild Engine and Airplane Corp. Prior to joining Fairchild, Chapline held positions as vice-president, sales, with Wright Aeronautical Corp., executive vice-president and president of Brewster Aeronautical Corp. His former position at Fairchild was vice-president and general manager, Fairchild Engine Division. He is a member of the SAE Aircraft Activity Committee.

RICHARD T. KARR has been elected a vice-president of Purolator Products, Inc. Karr, who has been with Purolator since 1937, is general sales manager of Equipment Division. Prior to that appointment he was assistant to vice-president in charge of sales.

CHARLES B. BENTON has been named vice-president in charge of national accounts for Fram Corp. Benton will continue to hold his previous post of vice-president in charge of sales and director of Fram Canada, Ltd.

J. J. HILT recently retired as vice-president, sales, with Young Radiator Co., after 32 years service. Hilt was sales manager with Young until 1936 when he became vice-president, sales. He was chairman of the SAE Milwaukee Section in 1935.

MARTIN T. DYKE has been named president of California Eastern Aviation, Inc. Dyke is president of Land-Air, Inc., a subsidiary of California Eastern, and will continue to hold that office.

DR. ROBERT M. KENNEDY has been appointed director of research and development with Sun Oil Co. Kennedy joined Sun Oil in 1941 as a research chemist and was named manager of basic research in 1953. Prior to his recent appointment he was associate director of research and development.

DR. CHARLES L. THOMAS has been appointed to the newly created position of scientific advisor with Sun Oil Co. This position frees Dr. Thomas of administrative responsibilities to permit his concentration on leadership in research and engineering. Formerly Thomas was director of the research and engineering department.

FRED J. WALLS has become vice-president, research and development, of Engineering Castings, Inc. He was formerly a metallurgist in charge of Detroit Technical Section of International Nickel Co., until his recent retirement.

JAMES A. MILLER has been appointed director of engineering of Minneapolis-Moline Co. In this position, he will direct the staff of engineers and designers at the Minneapolis-Moline experimental laboratory and engineering headquarters at Hopkins, Minn. Formerly Miller was chief engineer of gasoline powered Ford trucks with Clark Equipment Co.

J. F. DUNWIDDIE has been made general sales manager and director, N. V. Standard-Vacuum Sales Co. Previously he was manager of the Marketing Operations Department, Standard-Vacuum Oil Co.

JOHN B. BECKWITH, formerly engineering manager of Bristol Divisions, Associated Spring Corp., is now spring works manager, Bristol Divisions.

BERNARD L. SCHULMAN is now systems engineer with Denison Engineering Division of American Brake Shoe Co. In his new position he will

continued


McConkey


McCoy


Partridge


Taylor


Pulliam


Reese


Chapline


Karr

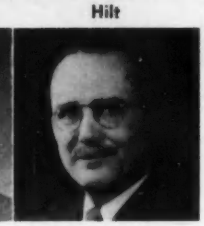

Benton


Hilt

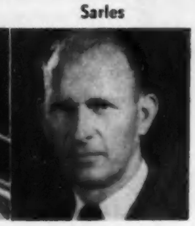

Mitchell


Sarles

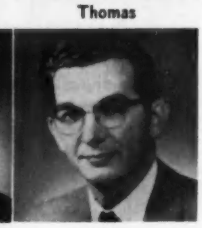

Kennedy


Thomas


Tognola


Bayless


Walls


Miller

SAE Members

continued

be concerned with research and development of feedback control systems for industrial applications of fluid power control. Formerly he was a dynamics engineer with Sikorsky Aircraft Division, United Aircraft Corp.

T. H. THOMAS has been made assistant general manager of the automotive section of Bendix Products Division, Bendix Aviation Corp. Thomas joined Bendix in 1933 as a technician in the vacuum power equipment laboratory. He also served as test engineer, assistant chief engineer, and chief engineer on vacuum power equipment. Prior to his recent appointment he was manager of automotive engineering.

CARL L. SADLER has been named vice-president in charge of Sundstrand Corp.'s aviation and defense products group — comprised of Sundstrand Aviation, Denver, and Turbo divisions. He had been vice-president and general manager of Sundstrand Aviation Division.

WESLEY J. KILEY has been appointed to the newly created position of general sales manager of Blackhawk Automotive Division of Blackhawk Mfg. Co. Kiley joined Blackhawk in 1950 and has been advertising manager, market planning manager and manager of distributor sales.

DONALD E. MILLER, former manager of Mound Road Engine plant of Chrysler Corp., has formed a new sales engineering organization, the D. E. Miller Co. The company will represent the various product lines of Colonial Broach & Machine Co. and its divisions from a sales and service standpoint.

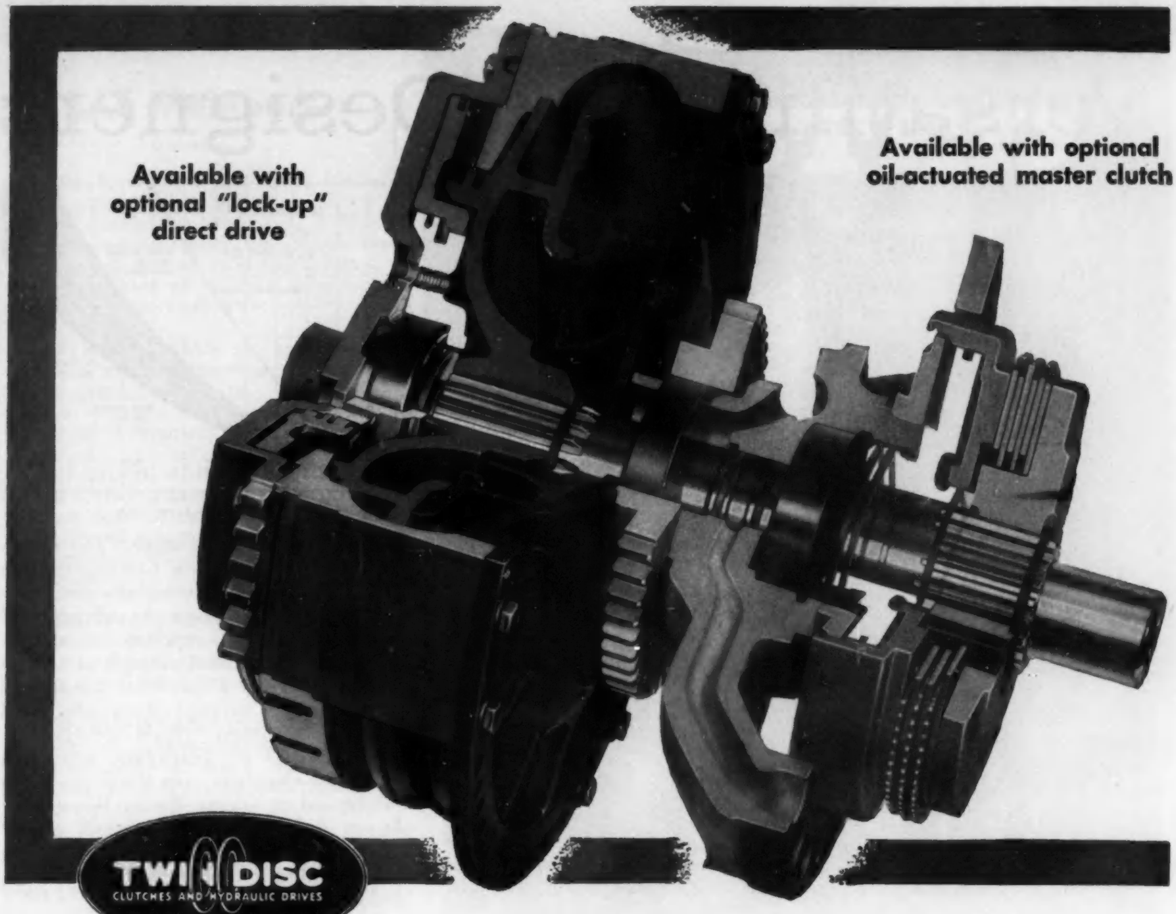

T. H. Thomas


Sadler


Kiley


Miller

continued



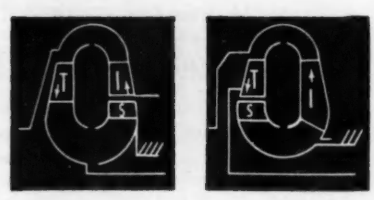
Twin Disc Single-Stage
STRIPPED Torque Converters

Efficiency, adaptability, long life — all in one low-cost, compact package — that's the new Twin Disc 1100 and 1300 Series Torque Converter. It's furnished as a "stripped" unit to be designed into any drive line of appropriate capacity. Wherever torque conversion is desired—shovels, cranes, tractors, materials handling equipment — this new unit provides compactness and low cost without sacrificing heavy duty construction.

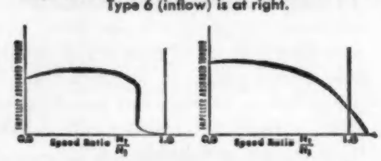
The 1100 Series is rated for engines producing up to 188 hp at 3700 rpm and up to 265 lb.-ft. of torque; the 1300 Series, up to 212 hp at 3200 rpm and up to 330 lb.-ft. Five torque ratings permit close matching of converter to engine for maximum efficiency and fuel economy. Torque converter eliminates engine lugging and stalling . . . cushions out shocks and vibrations . . . automatically matches power to load demands.

Considerable design latitude is provided by two optional circuit designs (see torque absorbtion characteristics at right).

This new "stripped" single-stage converter enables original equipment manufacturers to offer the sales appeal of torque converter drives at the lowest possible cost. See our catalog in Sweet's Product Design File, Folio 6a/TW. Write Rockford office for full details.



Schematic drawings of the two types of single-stage circuits. The Type 1 (outflow) circuit is at left. Type 6 (inflow) is at right.



A comparison of the torque characteristics of the Type 1 circuit (left) and the Type 6 circuit. The Type 1 circuit unloads the engine quite abruptly at a speed ratio of about .825. The Type 6 design allows a no-load speed ratio of 1.15:1.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

SAE Members

continued

JOHN S. DAVEY has been made vice-president in charge of sales for Russell, Burdsall & Ward Bolt & Nut Co. He was previously vice-president in charge of research and engineering. He is a member of the SAE Iron and Steel Technical Committee.

JAMES S. LANHAM has been made vice-president, engineering at Kent-Moore Organization, Inc. Previously he was special service tool manufacturer's chief engineer.

HOWARD H. KEHRL, formerly assistant staff engineer of the Engineering Laboratory, Chevrolet Motor Division, General Motors Corp., has become staff engineer, director of Engineering Laboratory.

DONALD L. CAUBLE, formerly chief engineer of Sundstrand Aviation Division, Sundstrand Corp., is now manager of Sundstrand Aviation.

G. R. BOUWKAMP has been made manager of automotive valve tappet manufacturing, Chicago Screw Co. Previously he was chief production engineer for the company's Tappet Division.

JAMES EWELL ERWIN, JR. has been promoted from service engineer to assistant chief engineer with Wilkening Mfg. Co.

continued

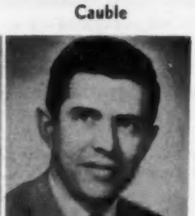
Davey

Lanham

Kehrl

Cauble

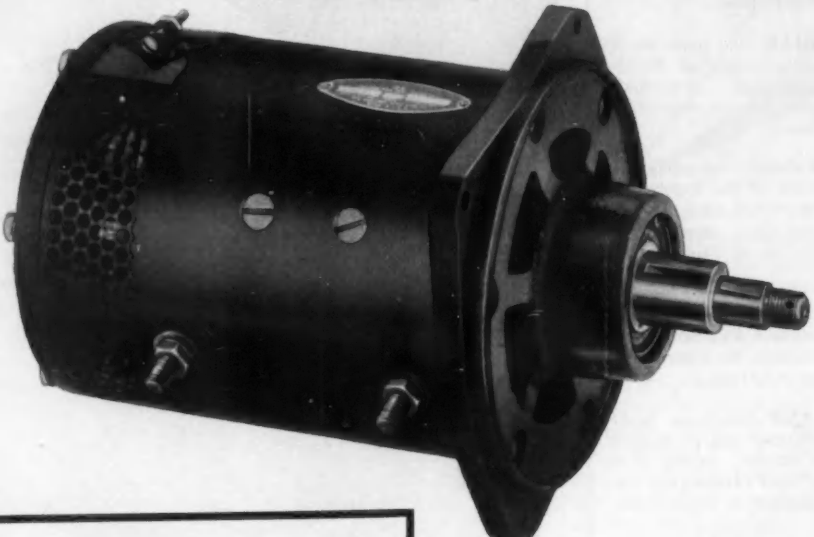
Bouwkamp



Erwin

NOW...FROM AUTO-LITE

NEW PUMP AND TRACTION MOTOR DESIGNS COMBINE VERSATILITY, DEPENDABILITY, STAMINA



NEW COST REDUCTION SERVICE FOR MANUFACTURER CUSTOMERS

Programs that include design, engineering, methods, automation and manufacturing are all contributing to the important new cost reduction service of the Electrical Products Group of Auto-Lite. Included are greatly expanded research and engineering activities, facilities for field training and service, and District Managers prepared to assist customers and prospects in their drive for lower costs.

More flexible than their names imply, Auto-Lite Pump and Traction motors are widely used for the many industrial applications that fall within the scope of their power and duty cycles. These series motors embrace a wide speed and torque range and almost all models meet the rigid specifications of the Underwriter's Laboratories. They operate at high efficiency with a low current draw so battery charging and maintenance is minimized. Here are a few outstanding Auto-Lite features:

1. AFBMA quality ball bearings—lifetime double sealed
2. Armature shaft designed to critical speed well above operating range
3. V-ring commutator construction—stabilized by seasoning
4. Armatures and field coils dipped and baked, on most models, to seal against moisture and dust

These motors are series wound, but shunt and compound wound motors can be supplied if required. Traction motors are reversible. Pump motors rotate clockwise facing drive end, but can be made counterclockwise if desired. For details clip the coupon opposite.

AUTO-LITE® ELECTRICAL PRODUCTS GROUP

THE ELECTRIC AUTO-LITE COMPANY, TOLEDO 1, OHIO

SAE Members . . . continued

MACY TEETOR HAS JUST DESIGNED and built the "Tandemaran" — a multiple hull boat — which is actually two catamarans in tandem. The design is the result of Teetor's attempt to solve a very well-known marine problem — loss in hull efficiency due to improper weight distribution.

The Tandemaran is essentially an all-aluminum houseboat, built on a frame supported by four aluminum hulls. Each hull carries one-fourth of the total weight and has a 35 hp outboard engine directly behind it. The four hulls provide a broad deck without the stress and strain problems of wide hulls. Also, considerably more material would be required to build a hull assembly of comparable size using two hulls in tandem.

Under the pilot's bay window, where all the controls are located, is a 5 kw, 110 v, aircooled powerplant which furnishes power for the pressure water system, for outside use, refrigeration, cooking-heating, airconditioning, water heater and lights.

The Tandemaran weighs a little over 7500 lb and has a top speed of 18 mph.

WALTER E. CARPENTER is now chief engineer of the Hudson Lamp Co. Formerly he was with the Lamp Division of Westinghouse Electric Corp.

WILLIAM M. BLAIR, formerly project engineer with Locomotion Engineering, Inc., is now a mechanical design engineer with Philco Corp.

CHARLES J. BENNER has become chief engineer for the automotive sales department, United States Rubber Co. His former position was sales engineer.

WILLIAM F. ELLIOTT, previously project engineer with FWD Corp., has become director of military engineering with FWD.

Obituaries

George R. Anderson . . . (A '56) . . . sales manager, Industrial Original Equipment Division, Weatherhead Co. . . . died April 11 . . . born 1919.

S. N. Castle . . . (M '18) . . . retired as vice president and secretary of Honolulu Rapid Transit Co., Ltd. of Hawaii . . . inventor of centrifugal oiling device for Corliss engines . . . died February 10 . . . born 1880.

Milburn C. Copold . . . (M '55) . . . manufacturing specialist, San Diego Division, Convair . . . died March 23 . . . born 1915.

Whitley C. Collins . . . (M '54) . . . president, Northrop Corp. . . . died May 12 . . . born 1898.

Raymond E. Greenough . . . (M '45) . . . vice president of engineering, Cleveland Pneumatic Tool Co. . . . died January 20 . . . born 1909.

J. L. E. Groff . . . (M '55) . . . scientific consultant, Institut Francais du Pétrole . . . died February 23 . . . born 1893.

Edward S. Janicke . . . (A '57) . . . fleet sales representative, Ford Motor Co. . . . died April 7 . . . born 1900.

L. Eric Jones . . . (M '49) . . . president, Delbar Products, Inc. . . . died February 25 . . . born 1911.

C. S. Johnson . . . (A '56) . . . automotive sales manager, Weatherhead Co. . . . died June 14 . . . born 1918.

Charles Henry Lewis . . . (M '43) . . . regional sales engineer, Standard Oil Co. of California . . . died March 5 . . . born 1906.

Paul Weeks Litchfield . . . (M '11) . . . retired, honorary chairman of board, Goodyear Tire & Rubber Co. . . . died March 18 . . . born 1875.

Continued

Obituaries . . . continued

John B. Landis . . . (A '55) . . . field representative, Auto Equipment & Service Co., Inc. . . . died February 6 . . . born 1901.

Wilfred H. Marty . . . (M '22) . . . manufacturing engineer, Fairchild Engine and Airplane Corp. . . . died March 4 . . . born 1896.

George D. McCormick . . . (M '30) . . . manufacturers' representative . . . died April 23 . . . born 1903.

Statton M. McKee . . . (A '31) . . . vice president, Nourse Oil Co. . . . died March 3 . . . born 1890.

Watt L. Moreland . . . (M '08) . . . retired truck manufacturer . . . organized Moreland Motor Truck Co. . . . died April 8 . . . born 1879.

Ralph H. Moyers . . . (M '46) . . . automotive laboratory instructor, Kamehameha School for Boys, Honolulu, Hawaii . . . died February 24 . . . born 1905.

Carl F. Norberg . . . (M '40) . . . president, The Electric Storage Battery Co. . . . died May 19 . . . born 1898.

A. S. Randak . . . (M '48) . . . manager, Technical Service, Sinclair Refining Co. . . . died May 5 . . . born 1912.

C. P. Roberts . . . (M '28) . . . professor, Department of Mechanical Engineering, Ohio State University, . . . died January 14 . . . born 1896.

Louis W. Shank . . . (M '32) . . . manager of suggestion system, Ethyl Corp. . . . died March 26 . . . born 1900.

Alfred M. Slagle . . . (M '29) . . . consultant . . . formerly with Bell Helicopter Corp. . . . died April 1 . . . born 1887.

Reber C. Stupp . . . (M '45) . . . vice president and general manager, DeVilbiss Metal Fabricators Co., . . . died May 11 . . . born 1900.

Walter E. Titchener . . . (M '23) . . . vice president and factory manager, Hackney Bros, Body Co. . . . died May 7 . . . born 1893.

Milton H. Van Alstyne . . . (M '56) . . . superintendent of Engineering Laboratory and Shop, Harrison Radiator Division, General Motors Corp. . . . died April 13 . . . born 1910.

Glenn S. Whitham . . . (M '15) . . . president and treasurer of Charles Street Garage, Boston . . . died March 24 . . . born 1889.

C. Edward Packer . . . (M '25) . . . automotive writer . . . died January 20 . . . born 1897.

Continued from page 92

committee are responsible for coordinating promptly the action needed in their respective departments.

The originator is informed promptly also if the proposal is rejected. . . . and he may request a reconsideration by addressing the chairman of the cost improvement committee.

To Order Paper No. 44S . . .
on which this article is based, see p. 6.

Sealing Fluids In Propulsion Systems

Based on paper by

A. A. LePERA

Wright Air Development Center

THE extreme environments in which propulsion system static and dynamic seals must operate include high energy fuels, extremely corrosive oxidizers, monopropellants, and cryogenic fluids, which must be retained to temperatures below − 400 F.

The majority of these systems are relatively low pressure, yet problems with elastomeric seal materials are even more pronounced than those met with the adverse mechanical conditions of high-pressure secondary power systems.

During elastomer compatibility studies with high energy fuels based on alkyl boranes, the Wyandotte Chemical Corp. discovered the most severe environment to occur during air aging following fuel immersion. The exothermic reaction produces an elastomer temperature above 1000 F when the volume swell exceeds 3% and is followed with air aging temperature above 450 F. A specific Viton A-HV compound has the best overall balance of physical properties, but is still not the ultimate to be expected.

Sealing one typical bipropellant system consisting of the oxidizer (inhibited red fuming nitric acid) and the fuel (hydrazine) is quite a challenge to both the material and design engineers. Fig. 1 shows the effects of hydrazine on various elastomers after 70-hr immersion at 250 F. Compounds of SBR (styrene butadiene rubber) and Hydropol V (hydrogenated butadiene polymer) are compatible with hydrazine up to 250 F for a maximum of 5 days. IRFNA, however, is a severe oxidizer and its effects on organic materials can be readily predicted. Kel-F 5500, Viton A, and butyl elastomers are resistant to IRFNA for a week at room temperature but increased temperatures accelerate elastomer degradation.

Elastomer compatibility with other potential bipropellants, such as liquid fluorine, nitrogen tetroxide, chlorine trifluoride, unsymmetrical dimethyl hydrazine, JP-X, and others, is under intense investigation by the Connecticut Hard Rubber Co., through a WADC Materials Laboratory contract.

Effects of Liquefied Gases

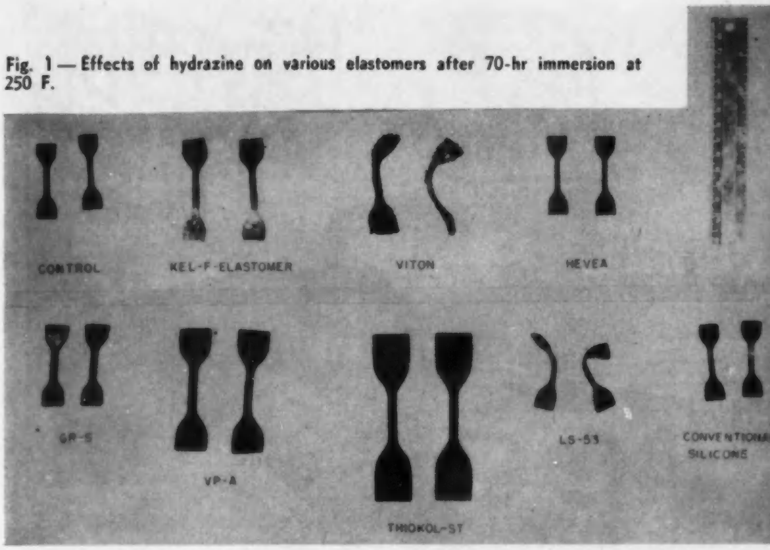
In addition to corrosive-type oxidizers there are the more common liquefied gases such as liquid oxygen used in combination with hydrocarbon fuels. Seal materials used in these cryogenic systems must be shock insensitive, resistant to embrittlement, and capable of withstanding excessive vibration and acceleration forces.

The most difficult sealing problems exist in the pneumatic components installed in the vicinity of cryogenic hardware. These components, usually pneumatic solenoid valve assemblies, are required to operate with minimum break-out force, low amplitude, and immediate response over the − 320 to 500 F range. Teflon, Kel-F elastomer and composites such as asbestos, stainless steel, and Inconel, have been tried, but their use is limited by poor resistance to cold flow, extremely close tolerances, and the high compressive stresses required to effect a seal.

Under Army Ordnance contract,

Continued

Fig. 1 — Effects of hydrazine on various elastomers after 70-hr immersion at 250 F.



General Electric has developed a temperature-sensitive seal, consisting of a Neoprene W gasket backed by an Invar insert, which employs temperature drop associated with confinement to establish the necessary gasket stress for the maintenance of a positive liquid oxygen static seal at temperatures down to – 297 F. The gasket stress increases as the temperature is lowered and is independent of the installation load used in assembling the coupling. This principle, along with several others, is being pursued through a WADC Materials Laboratory sponsored contract with the National Bureau of Standards to develop a static and dynamic cryogenic seal for temperatures down to – 452 F operation.

To Order Paper No. 50U . . .
on which this article is based, see p. 6.

Fuels Road Rated By 22 Labs for CRC

ROAD ratings of fuels with varying sensitivity and hydrocarbon composition are supplied in CRC Report 334, "Analysis of the 1957 Road Rating Exchange Data." In the 1957 program, 22 participating laboratories used 33 test vehicles of four different makes to determine the Modified Uniontown and Modified Borderline Road octane numbers of nine gasolines.

Data were analysed as follows:

- Accuracy of the fuel rating data was analysed by making statistical computations of the repeatability of ratings in a single laboratory and reproducibility of the ratings among the several laboratories. These were compared to similar analyses made for 1952, 1953, and 1954 road test programs.
- Linear regression equations were developed to relate vehicle octane numbers to laboratory fuel inspection properties.
- Graphs also were made to show the effect of fuel properties on vehicle ratings.

Results of the 1957 program revealed that:

(1) In general, precision of the road ratings compared favorably with that in past years.

(2) Linear regression equations indicated that a large portion of the variance in road ratings can be explained by laboratory octane number ratings and composition factors. However, in using the relationships developed from these data, it must be noted that only nine gasolines (mostly of the same aromatic content) were tested.

(3) Although regression coefficients have been computed for a large number of equation forms (all are reported because of their potential usefulness), detailed study has been restricted to a consideration of the equation:

$$\text{Road} = b_1R + b_2M + b_3O$$

where: Road = Road octane number
R = Research octane number
M = Motor octane number
O = Olefin content

This equation form in every case provides a better fit of the data than the simpler equations involving only Research and Motor method octane numbers as independent variables. The Research coefficient, b_1, in the above equation consistently decreases in magnitude with increases in engine speed. Conversely, the Motor coefficient, b_2,

Continued

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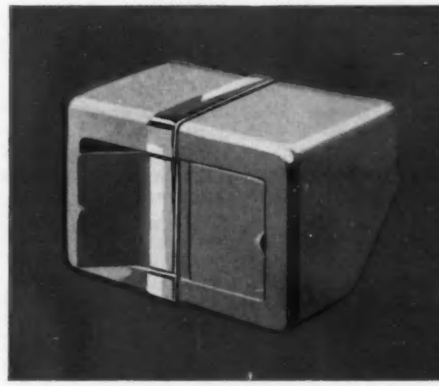

increases in magnitude with increases in engine speed.

(4) In general, both Modified Uniontown and Modified Borderline ratings decrease with increasing sensitivity if Research quality remains constant. Road octane numbers also decrease for a series of fuels of equal Research and Motor quality if olefin content is increased.

To Order CRC 334 . . .
on which this article is based, see p. 6.

Design Can Reduce Weapon Maintenance

Based on paper by

G. F. RABIDEAU

Norair Division, Northrop Aircraft, Inc.

MAINTENANCE costs far exceed the initial costs of weapons system equipment. According to an Air Force study, made in 1952, two dollars were spent per year to maintain each dollar's worth of airborne electronic hardware. Assuming an average life of five years, maintenance costs are 10 times the original equipment costs. Indications are that the same holds true for ground support electronic hardware.

There are five areas where deficiencies in design contribute to this high cost of maintenance. These areas and the items they affect are:

1. Accessibility — Installation, removal of components; servicing, adjustment of components; test point locations; work space.
2. Visibility and Legibility — Lighting of work areas; functional labeling of components; location of labels and marking.
3. Ease of Disassembly and Assembly — Number and type of fasteners; connectors; tool requirements; time involved in operation; possibility of incorrect assembly.
4. Component Weights and Dimensions — Manpower necessary to carry components; handles and other aids to portability; environmental restrictions.
5. Test Philosophy — Recognition of malfunction; gross isolation of trouble; fine isolation; application of self-checking; automated testing.

Black Box Examples

Lack of component accessibility is found characteristically in air vehicles and other systems which have sharply limited cubic dimensions into which many hardware items and their linkages must be placed. The primary cause of accessibility problems here, lies in the lack of an integrated design viewpoint. Far too often, engineers responsible for the design of black boxes plan their location within the airframe without reference to the effects up on the accessibility of other components. Consequently, systems enter the field with inaccessible test and servicing points, as well as difficult-to-remove components.

Interiors of black boxes are frequently inadequately lighted to permit easy servicing and maintenance. To require a maintenance man to hold a flashlight while working on such components can only decrease his efficiency.

Human engineering specialists can contribute to the solution of this problem created by deficiencies in design. There are eight sequential steps they can take for any weapon system. These are:

1. Analyze the human factors of maintenance functions.
2. Assist in determining maintenance manning requirements.
3. Provide human engineering support during initial design.
4. Assist in establishing maintenance procedures.
5. Carry out human engineering tests of developmental models.
6. Prepare human engineering recommendations for prototype design changes.
7. Evaluate system maintainability, using prototype equipment.
8. Make followup design recommendations.

To Order Paper No. 51R . . .
on which this article is based, see p. 6.

New Members Qualified

These applicants qualified for admission to the Society between June 10, 1959 and July 10, 1959. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Lloyd Shuler (A).

Baltimore Section

Richard B. Knox (A), Ed Hoyt Parkison (J).

Buffalo Section

Clarence J. Eckert (M), Wallace H. Wagner (A).

Central Illinois Section

John R. Aymer (J), Michael R. Gallagher (J), George E. Hammel, Jr. (A), Robert D. McFeeters (M), Dale Edward Pflederer (J), William D. Saathoff (M).

Chicago Section

Walter J. Kudlaty (M), Van K. Mefford (M), Edward Yatsko, Jr. (M).

Cincinnati Section

John D. Bourke (A).

Cleveland Section

Robert A. Cohill (A), Alfred W. Tucker (M).

Dayton Section

William F. Erickson (M).

Detroit Section

Kenneth L. Buck (J), F. Dale Buerstetta (M), William C. Erdman (M), Robert L. Everett (J), George Charles Farhood (M), Harold R. Grant (M), Glenn R. Green (M), Merrill L. Haviland (J), Othello M. Hillman (M), Z. Louis Horvath (M), Kenneth Martin Jordan (J), Ernest P. Kiraly (M), Harold William Krauss (J), Philip O. Mastin, Jr. (A), William Nagy (M), J. H. Nourse (M), Clayton F. Paquette (M), Matthew C. Patterson (M), William Edward Rowe (M), Frederick W. Sabur (M), Bruce M. Scott (A), Robert E. Shelhart (M), Virgil Reed Stump (M), William G. Welsh (M).

Fort Wayne Section

A. R. Clark (M), Jack Covitt (M), Robert J. Pielsticker (M).

Indiana Section

Charles L. Dusenberry (J), Richard Howard Duzan (M), Attila Frank Jeney (J).

Kansas City Section

Henry Thomas Fryc, Jr. (A), Evan L. Hopkins (A), A. S. King (M), Arnold L. Spurlock (M).

Metropolitan Section

Louis Achitoff (M), Dickerson F. Cutler (J), Frank G. Daleo (A), D. F. Ferris (M), Lindsay Payne (M), Thomas John Rhodes (M), Kenneth J. Skoglind (J), John W. W. Sullivan (M), Warren C. Wilson (M).

Mid-Continent Section

John H. Shroyer, Jr. (J).

Mid-Michigan Section

Thomas G. Gorman (J), George W. Lamoreaux (M), John Donald Leighton (A), Harrison T. Price (M), Ernest J. Ross (M), R. B. Wells (M).

Milwaukee Section

Robert J. Hackett (M), Lloyd Frederick Sippel (J).

Montreal Section

Tibor Dancs (M), Trevor Williamson (J).

. . . continued

New Members Qualified

Continued

New England Section

Jerome Ruzicka (J).

Northern California Section

E. P. DeBerry (A), Donald A. Fraser (A).

Northwest Section

Clifford T. Thompson (J).

Ontario Section

Robert Ivan Hillmer (A), John William Lambert (A), Andrew Cameron Lyon (M).

Philadelphia Section

Albert C. Condo, Jr. (M), Robert J. Fritz (A).

Pittsburgh Section

William F. Hughes (M).

Rockford-Beloit Section

Rober Eugene Miller (M).

Salt Lake Group

Lionel George Wildey (M).

San Diego Section

Paul Robert Becker (A), Robert L. Clark (M), George D. Johnson (J), Kenneth V. Lawson (M).

South Texas Group

Cipriano Gonzalez (A).

Southern California Section

William F. Bradley (A), David A. Bryson (A), Jose Gonzalez (A), Ralph M. Kerstner (J), A. Lawrence Stone (M).

Texas Section

Lowell B. Baird (A), R. C. deWaal (M).

Texas Gulf Coast Section

Joseph D. Koza (M), William Bernard Nelson, Jr. (J).

Twin City Section

William B. Kletzin (M).

Washington Section

Fred C. Fielding (J).

Wichita Section

Samuel Sanner (A).

Williamsport Section

John Joseph Penkoske (M).

Outside Section Territory

George S. Allin, Jr. (M), William A. Best (J), Millard J. Kyle (M), Alan Macdonald, Jr. (M), George E. Nichols (M), Raymond T. Zwack (M).

Foreign

Charles Guinard (M), France; Arie Matus (A), Israel; F. W. Mead (A), So. Africa; Vadali Papahara Sarma (J), India; A. J. Schilling (M), France.

Applications Received

The applications for membership received between June 10, 1959 and July 10, 1959 are listed below.

Atlanta Section

W. R. Hill, Sam B. Howard, Jr.

British Columbia Section

Ronald Buckoll, Gordon Edward Stewart

Buffalo Section

William E. Cotter, William C. Platko

Central Illinois Section

J. H. Ashton, William R. Hawks, Keith E. Koch, Ralph Gene Nelson, Bernard E. Swanson

Chicago Section

Arthur Lyle Bloomfield, Thomas Atkin Brandson, Jr., I. T. Fritz, Thomas L. Kmieciak, Carl E. Overton, Frank J. Stefanov, Dale Stanley Wahlstrom, Granville Woolman

Cincinnati Section

Lawrence Naber

Cleveland Section

W. R. Kanda, James Paul Lucas, James Dennis McCabe, Bradley A. Pritts, Kendall C. White.

Dayton Section

Donald Eugene Brammer

Detroit Section

Philip Robert Austin, Richard P. Baribault, Albert R. Chick, Joseph C. Coyne, Walter Waldo Cross, Elmer Howard Diedrich, Douglas Richard Dixon, Laurence G. Feiler, Jr., James A. Groening, George Edward Harland, August J. Hofweber, Albert M. La Rou, Franklin A. Miller, Carleton L. Pierpont, Vernon Schafer, Jr., Clark R. West, Ralph C. West

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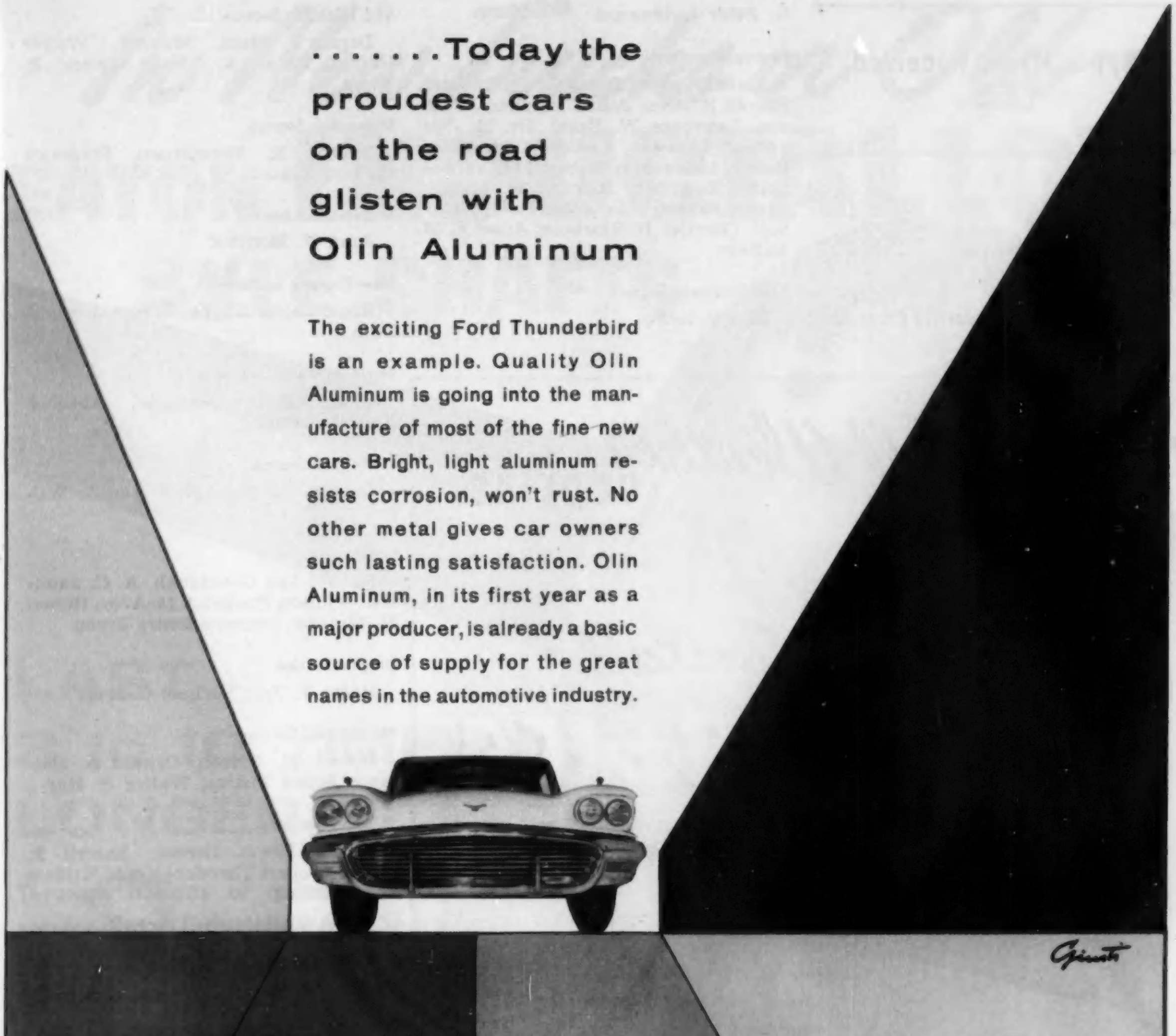
.......Today the proudest cars on the road glisten with Olin Aluminum
The exciting Ford Thunderbird is an example. Quality Olin Aluminum is going into the manufacture of most of the fine new cars. Bright, light aluminum resists corrosion, won't rust. No other metal gives car owners such lasting satisfaction. Olin Aluminum, in its first year as a major producer, is already a basic source of supply for the great names in the automotive industry.
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Applications Received

Continued

Fort Wayne Section

Benjamin Feierstein

Indiana Section

G. Ott Coleman, Paul C. Kline, Jr., N. Peter Lavengood

Metropolitan Section

Joachim Aue, Bruce H. Carpenter, Harold E. Deen, James Edmund Erickson, Lawrence W. Fagel, Dr. H. Paul Julien, Ladislav Kadlec. Christopher Robert Landmann, Robert McKay, 3rd, Gilles X. Mellet, Richard W. Melosh, James Robert Nile, John Robert Provost, Guenter H. Storbeck, Ansel E. M. Talbert

Mid-Continent Section

Don E. Lewis

Mid-Michigan Section

Dennis Milton Manner, Walter Ruddy, Ralph E. Towne, Duane E. Wood

Milwaukee Section

Eugene M. Hermansen, Frederick Carlton Klaus

Montreal Section

John P. Mentink

New England Section

Roger Owen Gagne, Robert J. Hamilton

Northern California Section

Aldo Mario Germano, Anthony Robert Rivera

Northwest Section

George Edward Eaton, Joe D. Wilson

Ontario Section

Ronald Lee Greenough, A. C. Jamison, William Frederick McAvoy, Robert M. Murphy, Richard Henry Syson

Oregon Section

Harry E. Joy, Michael C. Kaye

Philadelphia Section

Robert M. Cytron, Oswald A. Holland, Arpad Miklos, Walter S. Ray

St. Louis Section

Jerald Edwin Drewel, Sherril F. Glover, Robert Theodore Koch, William Allan Strong

South Texas Group

Satyakar Nath Agrawal

Southern California Section

C. V. Bennett, Franklyn B. Floren, Richard Joseph Gardner, Thomas V. Jones, Martin Kroll, Raymond H. LaFontaine, Roy C. Morris, Mitchell Harvey Seidman, Paul E. Thornton, Ray A. White

Texas Section

William W. Boyd

Twin City Section

Morris W. Wisti

Wichita Section

Leonard Harry Reimer

Outside Section Territory

Robert Carlyle Anderson, Hedley R. Colby, Ronald Alan Munier, Richard J. Pryor, Jr., Robert E. Rockefeller, John Harold Slike

Foreign

Aristides S. Akantisz, Austria; Robert Buty, France; Alfredo Dominquez, Colombia; Roberto Gregori, Brazil; James A. Hulme, Trinidad, West Indies; Ernst Herman Krauss, Australia; Paul Pinier, France; Werner K. Schmidt, West Germany


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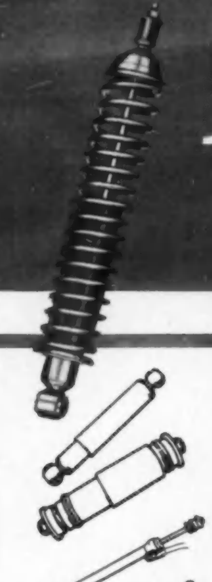

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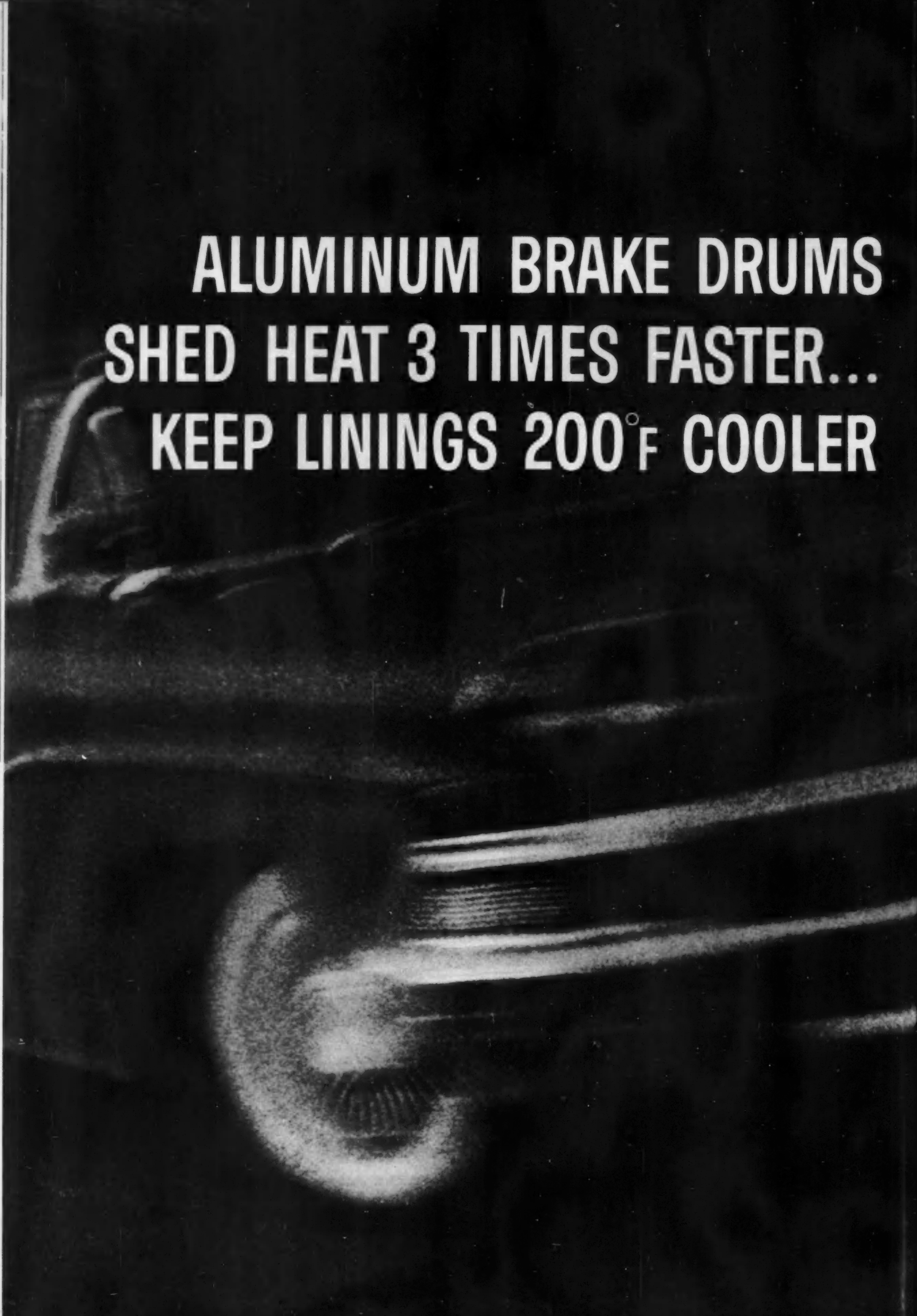
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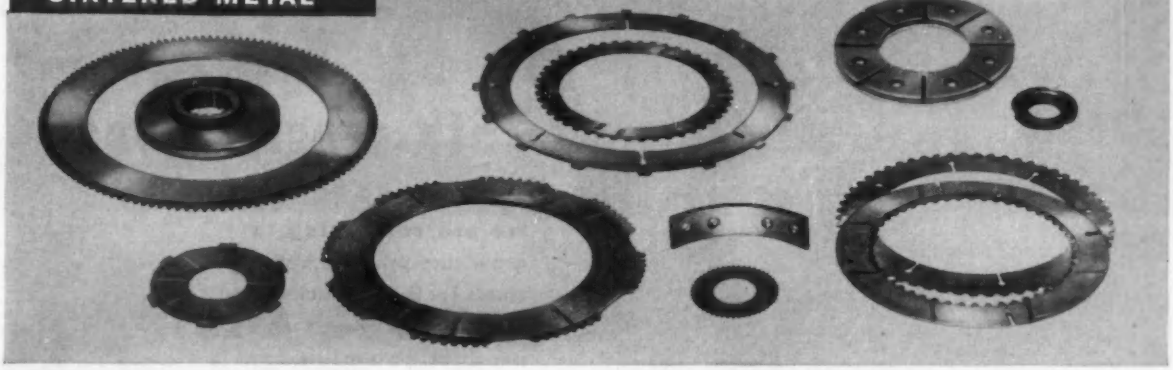
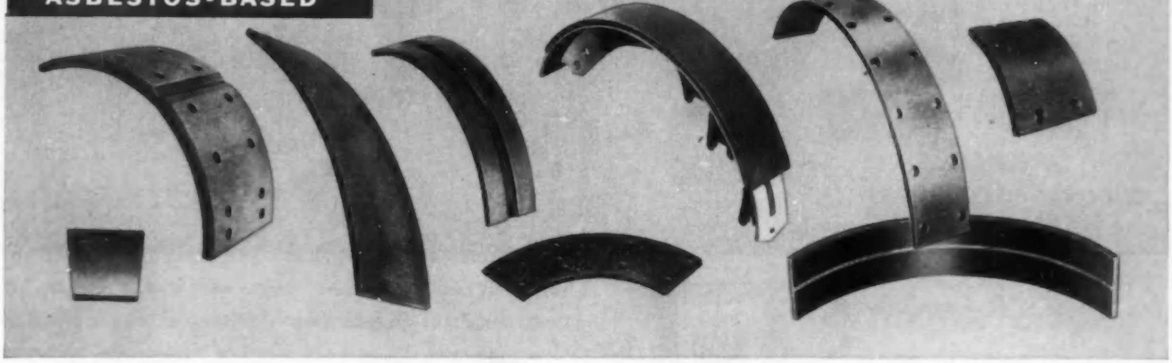


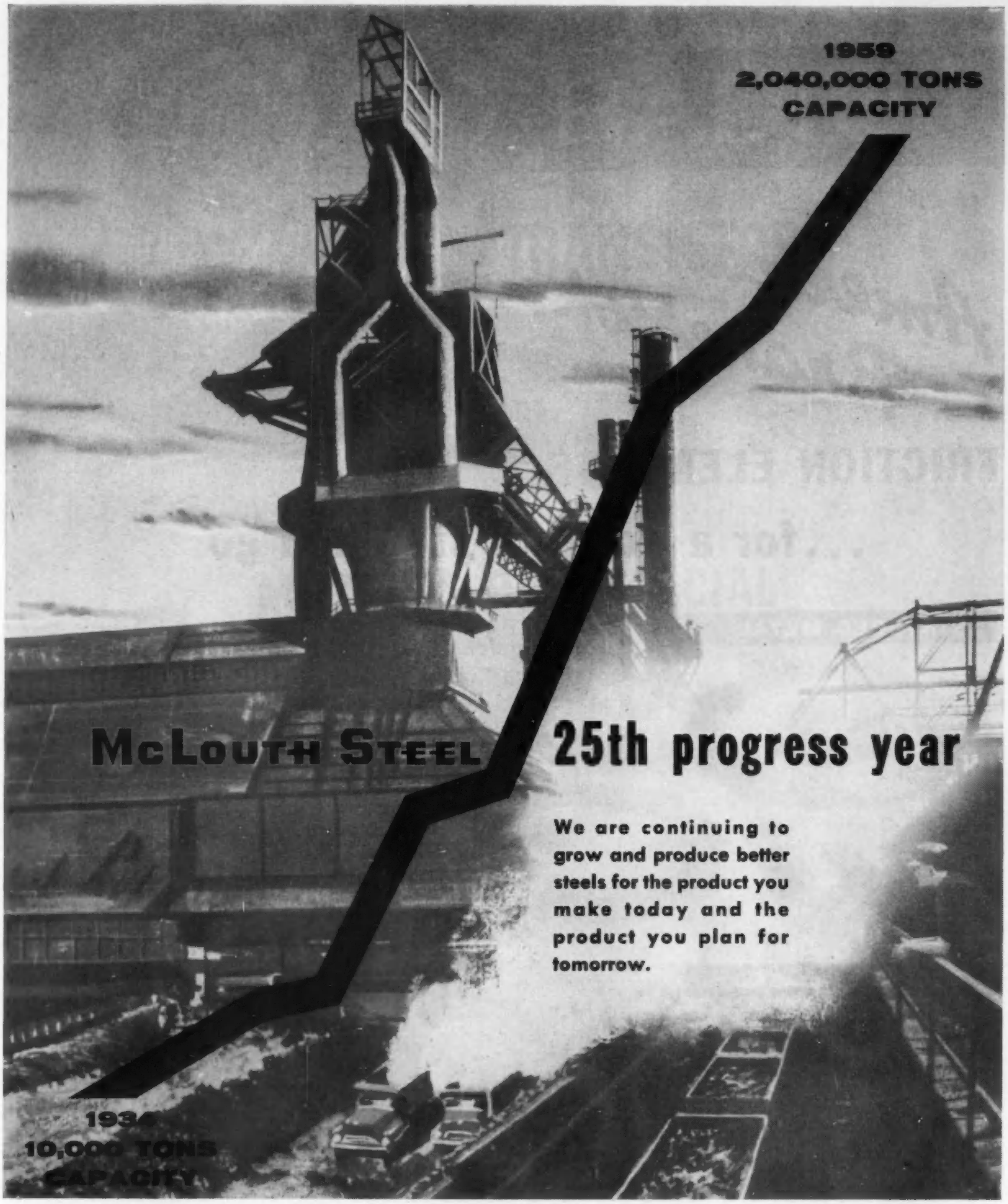
ASBESTOS-BASED

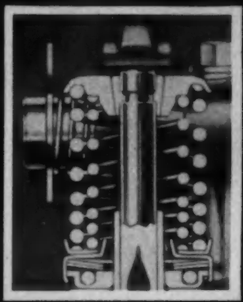


Brake Shoe

AMERICAN BRAKEBLOK DIVISION

P.O. BOX 21, BIRMINGHAM, MICHIGAN


1959
2,040,000 TONS
CAPACITY
McLOUTH STEEL
25th progress year
We are continuing to grow and produce better steels for the product you make today and the product you plan for tomorrow.

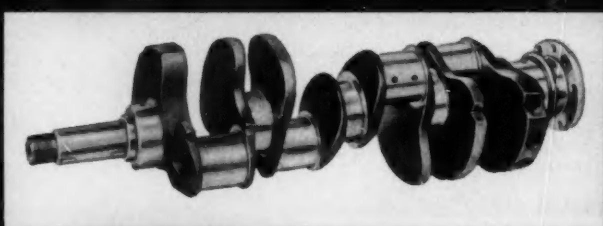


POSITIVE ROTATORS
on all exhaust valves

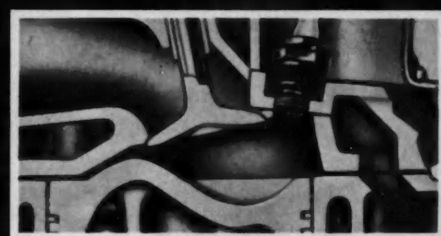
UV-549
257 max. eng. hp.

HEAVY-DUTY LUBE
OIL COOLER is
standard equipment

COUNTERBALANCED
CRANKSHAFT
is rigid, deflection-free



MACHINED COMBUSTION
CHAMBERS for uniform
compression ratio in all cylinders



Get more power per dollar with V-8's that rank first in 206 to 257 hp. class

Three new International V-8's—the UV-549, UV-461 and UV-401—are power, price and performance leaders in the 206 to 257 max. engine horsepower classification. Each of the three heavy-duty models give you more power per dollar...the surest way to put an extra sales feature in your products. And the power curves for these better breathing V-8's are certified—not hopeful guesses of what the engine may or may not deliver.

Each engine is available with factory-installed carburetion equipment to burn the fuel of your choice—gasoline, LPG or natural gas.

Get complete details on any of these No. 1 rated V-8's by writing or calling International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Illinois.

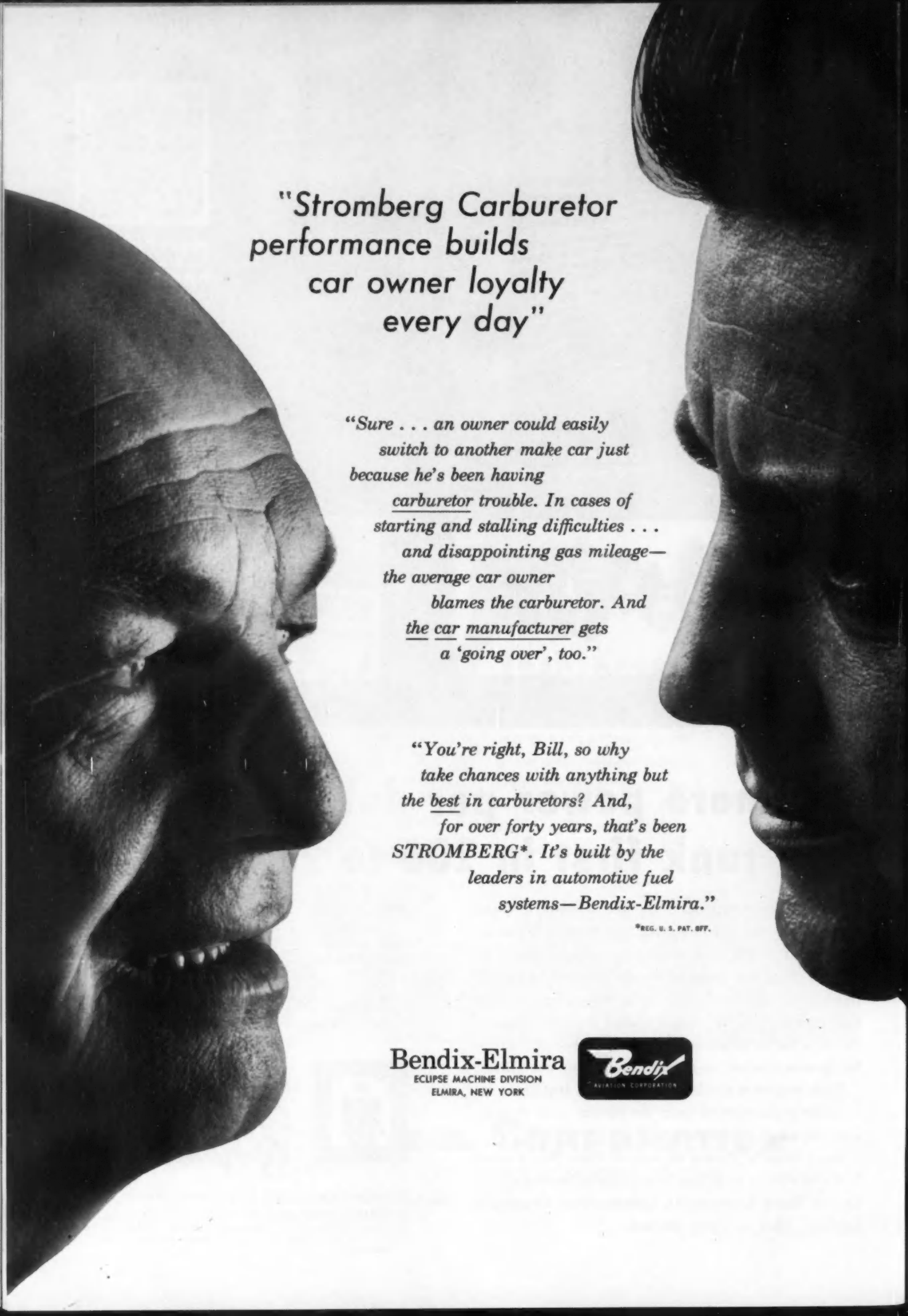
BRIEF SPECIFICATIONS

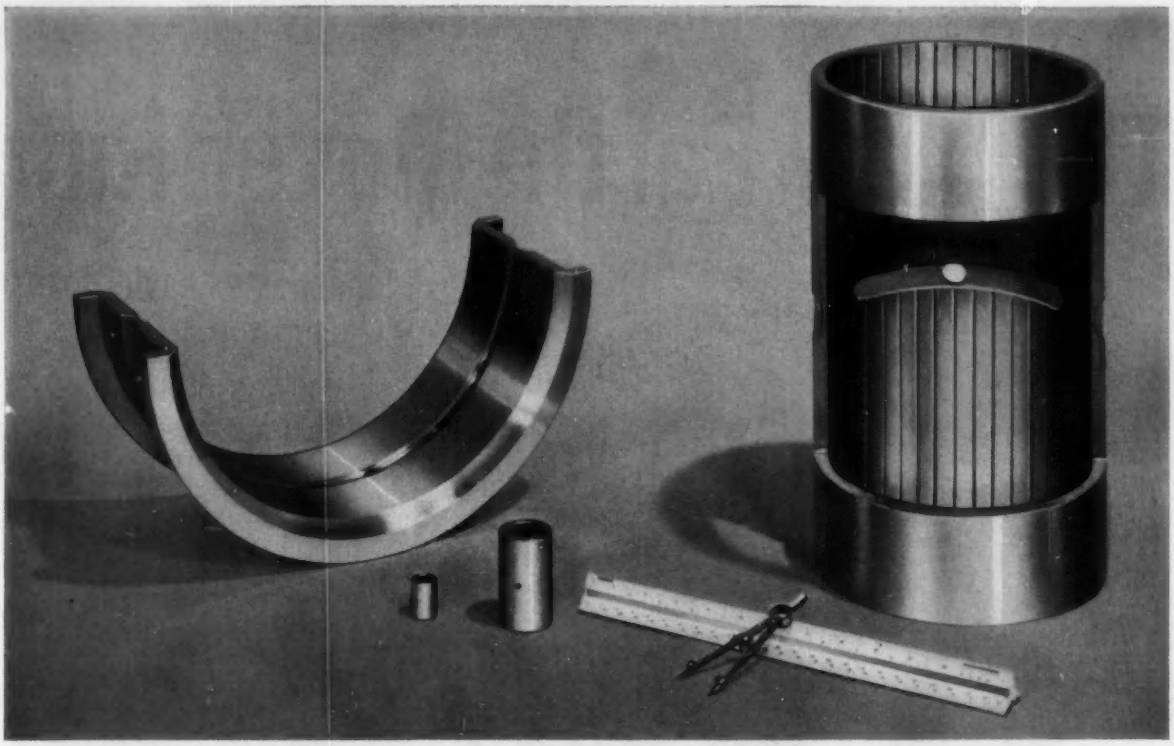
MODEL	UV-549	UV-461	UV-401
Eng. Max. Hp. (gaso.)	257 @ 3400 rpm	226 @ 3600 rpm	206 @ 3600 rpm
Power Unit Net hp:			
gaso	208 @ 2600 rpm	170 @ 2600 rpm	160 @ 2800 rpm
LPG	201 @ 2600 rpm	166 @ 2600 rpm	155 @ 2800 rpm
nat. gas	178 @ 2600 rpm	153 @ 2600 rpm	132 @ 2800 rpm
Bore and Stroke	4½ x 4 5/16	4⅛ x 4 5/16	4⅛ x 3¾
Displacement cu in.	549	461	401

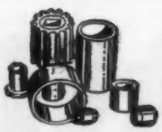
International® Construction Equipment

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

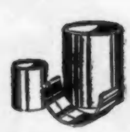

"Stromberg Carburetor performance builds car owner loyalty every day"
"Sure . . . an owner could easily switch to another make car just because he's been having carburetor trouble. In cases of starting and stalling difficulties . . . and disappointing gas mileage— the average car owner blames the carburetor. And the car manufacturer gets a 'going over', too."
"You're right, Bill, so why take chances with anything but the best in carburetors? And, for over forty years, that's been STROMBERG*. It's built by the leaders in automotive fuel systems—Bendix-Elmira."
*REG. U. S. PAT. OFF.
Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, NEW YORK
Bendix
AVIATION CORPORATION



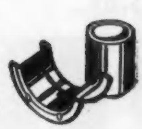


POWDER METALLURGY—BRONZE OR IRON

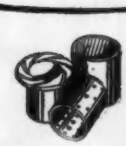
ALUMINUM ON STEEL SOLID ALUMINUM



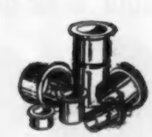
BRONZE ON STEEL



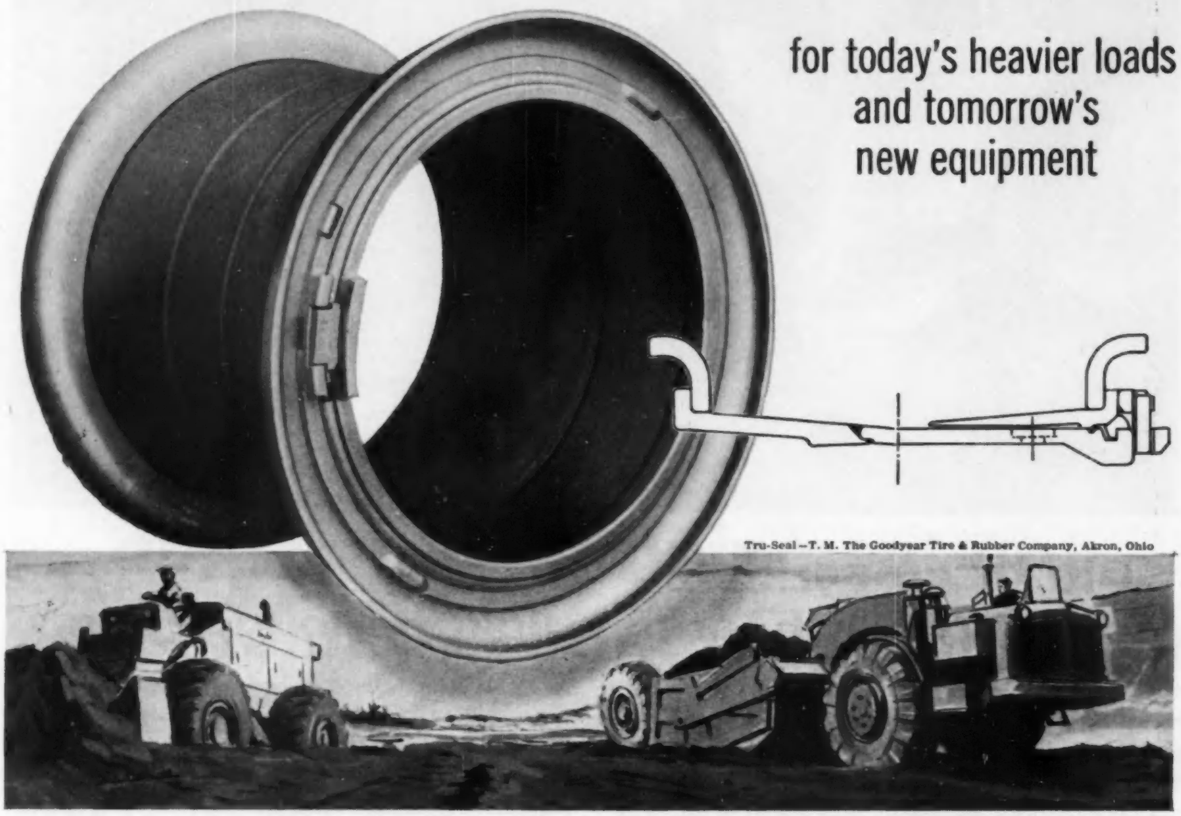
STEEL AND BABBITT

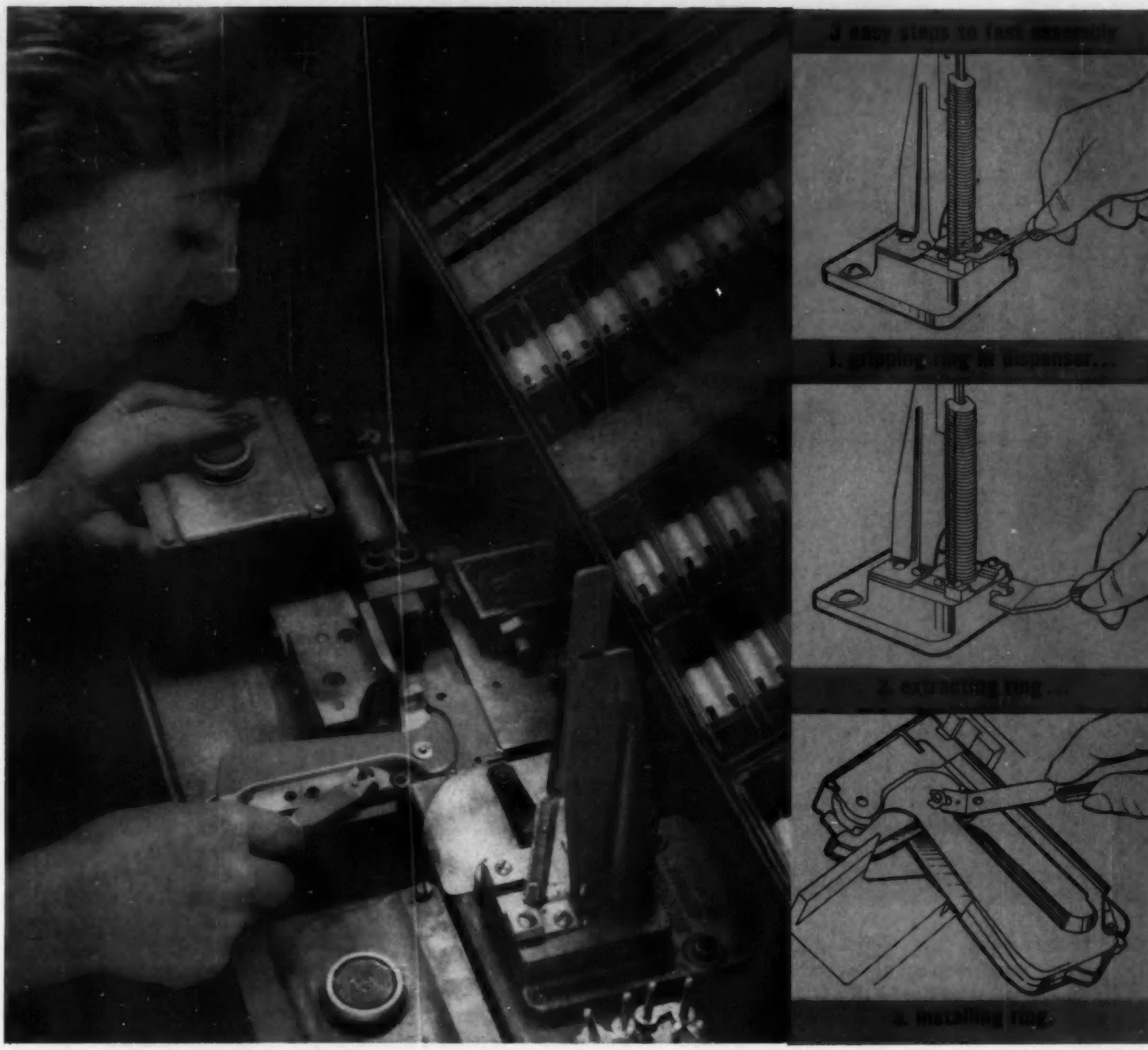


GRAPHITED BRONZE



BRONZE—CAST OR ROLLED


for today's heavier loads
and tomorrow's
new equipment
Tru-Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio



Truarc rings and dispenser speed staple gun assembly 60%

This big production increase was made by Swingline, Inc., Long Island City, N. Y. in assembling the handle lock of their high-compression staple gun.

To speed production, the Truarc Prong-Lock® Series 5139 retaining rings come *pre-stacked* for use on the Truarc *dispenser* (shown in foreground of photo above). Application is simple, fast and requires no skill. The operator, using the Truarc *applicator*, grasps the bottom ring, removes it from the stack, and installs it, quickly and easily, in the staple gun assembly.

The Truarc ring replaced an ordinary flat "C" washer, previously used in this application. *While the unit cost of the washer was lower than that of the Truarc retaining ring, the use of the rings resulted in assembled cost savings of $25.00 per thousand staple guns.* The reasons: a 60% increase in production due to faster, easier assembly with Truarc tools, and the elimination of time-consuming, costly adjustments made possible by Truarc rings. What's more, the bowed Prong-Lock ring improved product design by providing resilient end-play take-up... eliminating looseness or binding in the parts.

Truarc retaining rings come in 50 functionally different types... as many as 97 different sizes within a type... 6 metal specifications and 13 finishes. Truarc assembly tools, pliers, applicators, dispensers and grooving tools are available to speed production of virtually every kind of product. Make sure you have on file the new 16-page Waldes Truarc Assembly Tool Catalog No. AT 10-58. Write for your copy today. And remember Waldes engineers are always ready to help you solve your special application problems. Waldes Kohinoor Inc., 47-16 Austel Place, Long Island City 1, N. Y.

 9.2

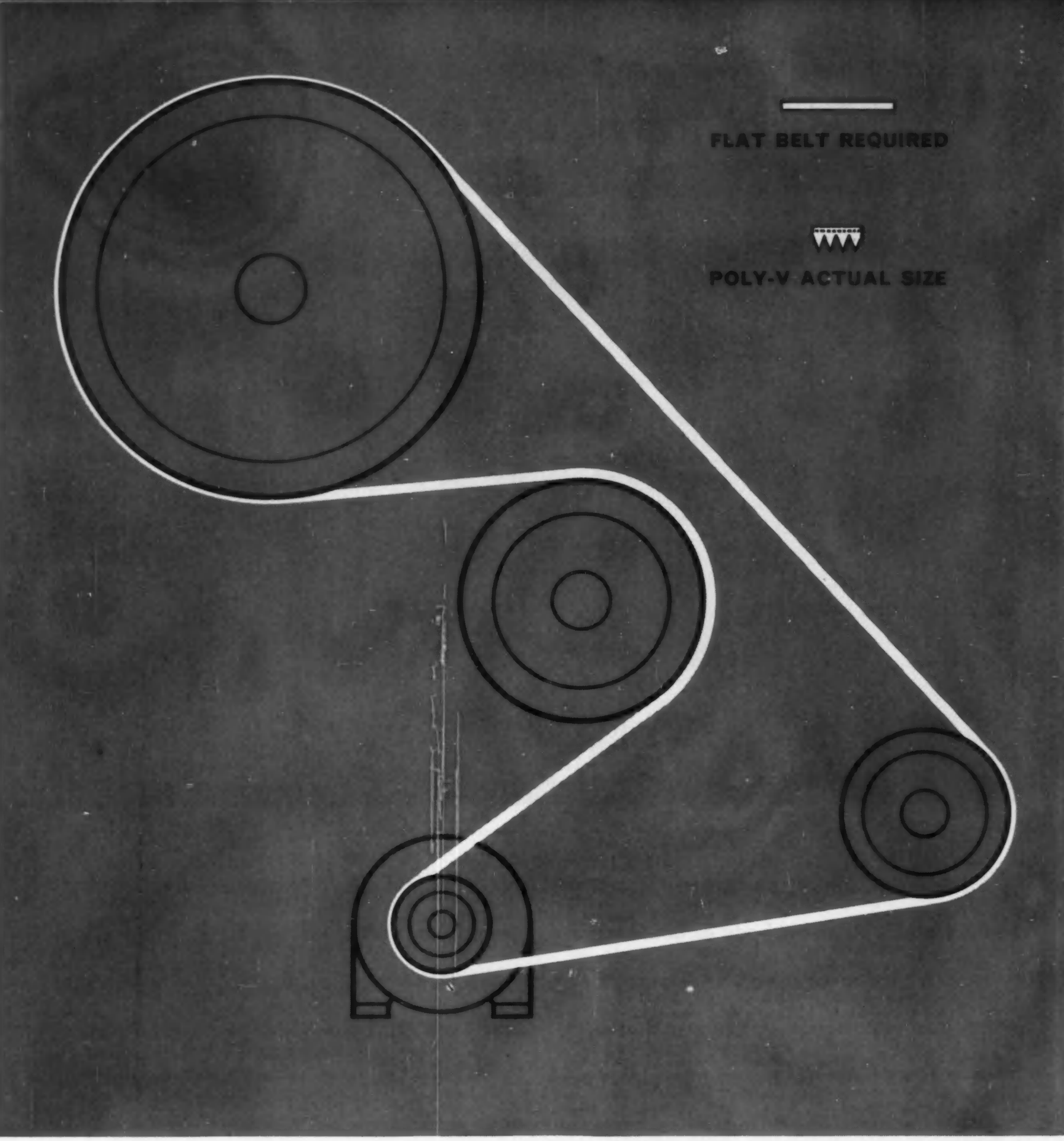
WALDES

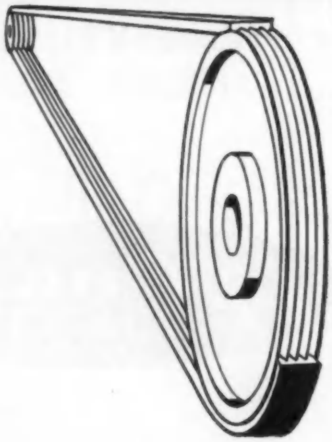
TRUARC®

RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS... THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS





COMPACT, MODERN AUTOMATIC WASHER

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton Poly-V Drive. Note that it imposes three design requirements, (1) a torturous back bend (2) subdiameter pulleys (3) a limited tension take up area. Yet the design is efficient because Dayton V-belt engineers applied Poly-V to overcome these three punishing conditions.

As you can see, use of Dayton Poly-V results in important savings in space, weight and costs . . . a more compact and lighter drive because of greater flexibility and load carrying capacity. You'll also find that Dayton Poly-V drives protect you against expensive "warranty" service calls.

Trailer constructed of corrugated, strong, nickel-containing stainless steel on top and sides, polished stainless front and rear, has modern good looks. Gives extra years of low-upkeep service. Made by Fruehauf Trailer Company.

Put more sell into trailers with stainless steel

See what you can do with nickel-containing stainless steel to boost cargo space ... service life ... appearance

Look into the dollars-and-cents advantages you can put into trailers with nickel-containing stainless steels:

High strength permits use of lightweight, thin-gauge sections for:

(1) more payload – trailer is stronger, not heavier.

(2) more inside space – wall bracing is compact.

Corrosion resistance gives:

(1) long service life – resists storm, spillage.

(2) low upkeep – no painting needed; cleans easily.

There are other advantages—tough, hard, nickel-containing stainless steel provides exceptional durability – it's harder to scratch or damage. The corrugations give the unit additional longitudinal strength, rigidity.

You'll likely find several more ways to use low-upkeep, durable, nickel-containing stainless steels. For latest information on these versatile metals, write Inco:

Rear view, showing corrugated stainless steel roof and bows.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STAINLESS PERFORM BETTER LONGER

PROVEN PRODUCTS FOR THE FOUNDRY INDUSTRY

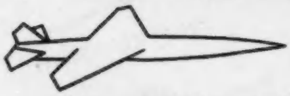
RCI

Creative Chemistry ...Your Partner in Progress

Self-Curing Oil Binders; Sand Conditioners; Phenolic Shell Molding Resins; Phenolic, Amino and Alkyd Core Binders

When close tolerances are vital

RCI FOUNDREZ INSURES ACCURACY IN HICA SHELL MOLDING PROCESS

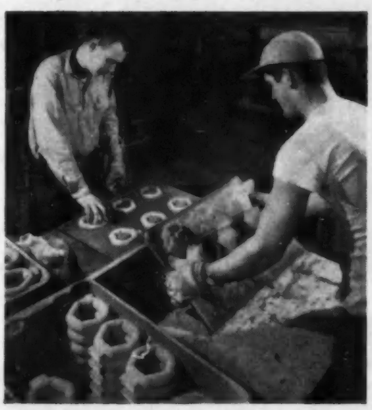


Shreveport, La. —HICA, INC., reports that shell molds made with Reichhold's FOUNDREZ 7504 powdered phenolic resin produce "High Integrity CAstings" for manufacturers of chemical and milk processing equipment, aircraft, missile, pump, valve and burner parts. HICA pours stainless and other alloys on intricate jobs requiring extremely close tolerances.

HIGHEST DEPENDABILITY

In a recent interview Phillip R. Johnson, HICA shell molding foreman, said "The dependability of RCI's FOUNDREZ recently helped us supply a large order of complicated castings without a single reject by our customer. With FOUNDREZ, we are able to avoid the warpage and cracking frequently encountered with other resins. Nor have we experienced any problem that could be attributed to our use of FOUNDREZ."

HICA'S *shell molding department. Up-to-date methods and machines help produce accurate, economical castings.*



HICA *team ready to close cope and drag halves of plug valve handle adapter mold after cores have been set in place.*

ECONOMY IMPORTANT

Besides dependability and quality, economy played a significant part in HICA'S choice of FOUNDREZ. "The superior bonding qualities of RCI's FOUNDREZ 7504," said Mr. Johnson, "allow us to use less resin per pound of sand, affording us substantial savings in our production run. It's easy to see why we use FOUNDREZ exclusively in all our shell molding techniques."

VARIETY OF RESINS

Reichhold's FOUNDREZ 7500 series of powdered phenol-formaldehyde resins, designed especially for shell molding, includes:

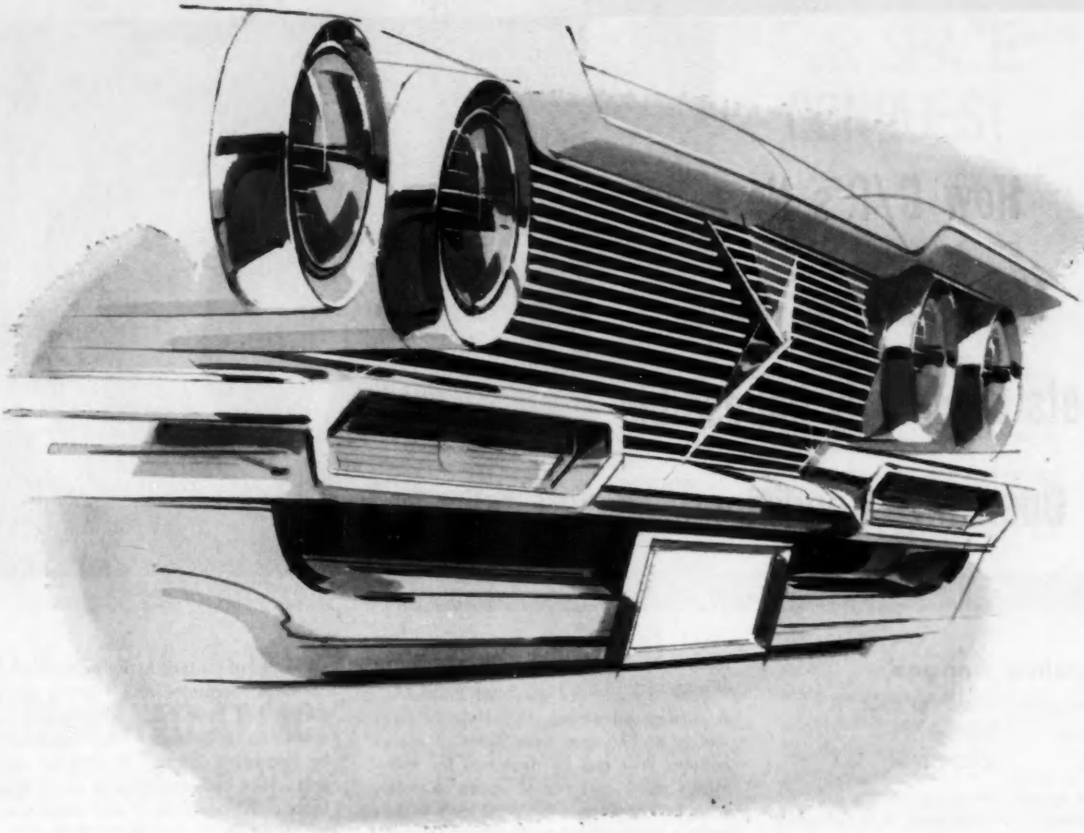
FOUNDREZ 7500 — a general purpose phenol-formaldehyde resin. Features long flow and cure. This product is especially applicable to intricate-pattern work.

FOUNDREZ 7504 — formulated for intermediate flow and long cure properties. Ideal for the jobbing shop where many different types of castings are made. May be employed on a variety of pattern contours.

FOUNDREZ 7506 — has the shortest flow and fastest cure of the series. Compounded for high speed production of shells. Most suitable where foundry production involves long runs of a few types of castings.

If you would like further information on the FOUNDREZ 7500 series, write for Technical Bulletin F-3-R. Reichhold Chemicals, Inc., RCI Building, White Plains, New York.

"Wood Be" torsion suspension
by Mather about 475 B. C.



FIRESTONE GIVES YOUR CARS NEW "COME ON" WITH *fashionized* ALUMINUM PARTS

Call on Firestone's fabricating and finishing abilities in mass-producing colorful, low-cost parts and trim for automotive products.

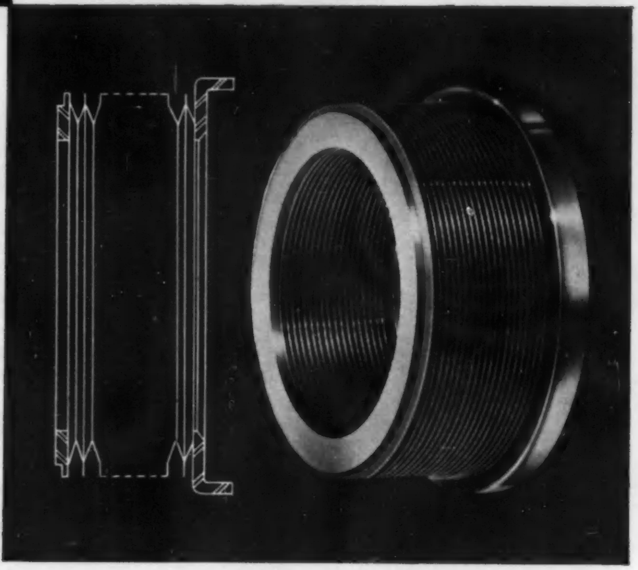
Call on the brightest brightwork in the business to turn comparison-shoppers into your new customers. Call on the eye-catching colors and qualities of aluminum formed and *Fashionized* by Firestone to supply new competitive appeal inside and out.

Call on *Fashionized*® Aluminum, and on Firestone's more than 50 years of metal-fabrication experience. Call, too, on the production capacities and competitive prices that only an automated anodizing line can supply —in part sizes up to seven feet long. Your inquiries and inspections are cordially invited.

FIRESTONE FASHIONIZED ALUMINUM
FIRESTONE STEEL PRODUCTS COMPANY, AKRON 1, OHIO

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1243 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

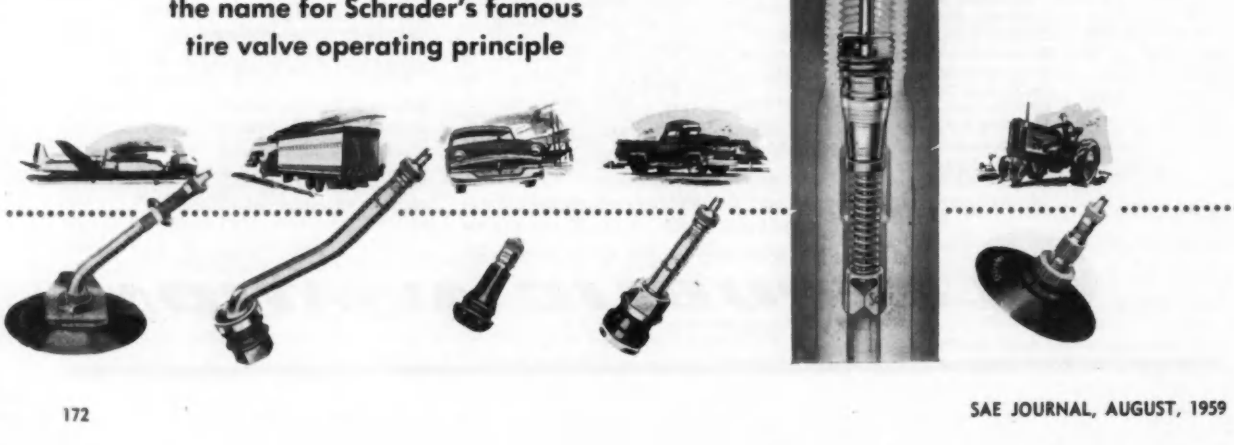
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

ANYWHERE IN THE WORLD...ANYONE

ACE OF STANDARDIZATION

the name for Schrader's famous tire valve operating principle




...OR IN PAPEETE, TAHITI...
826-T

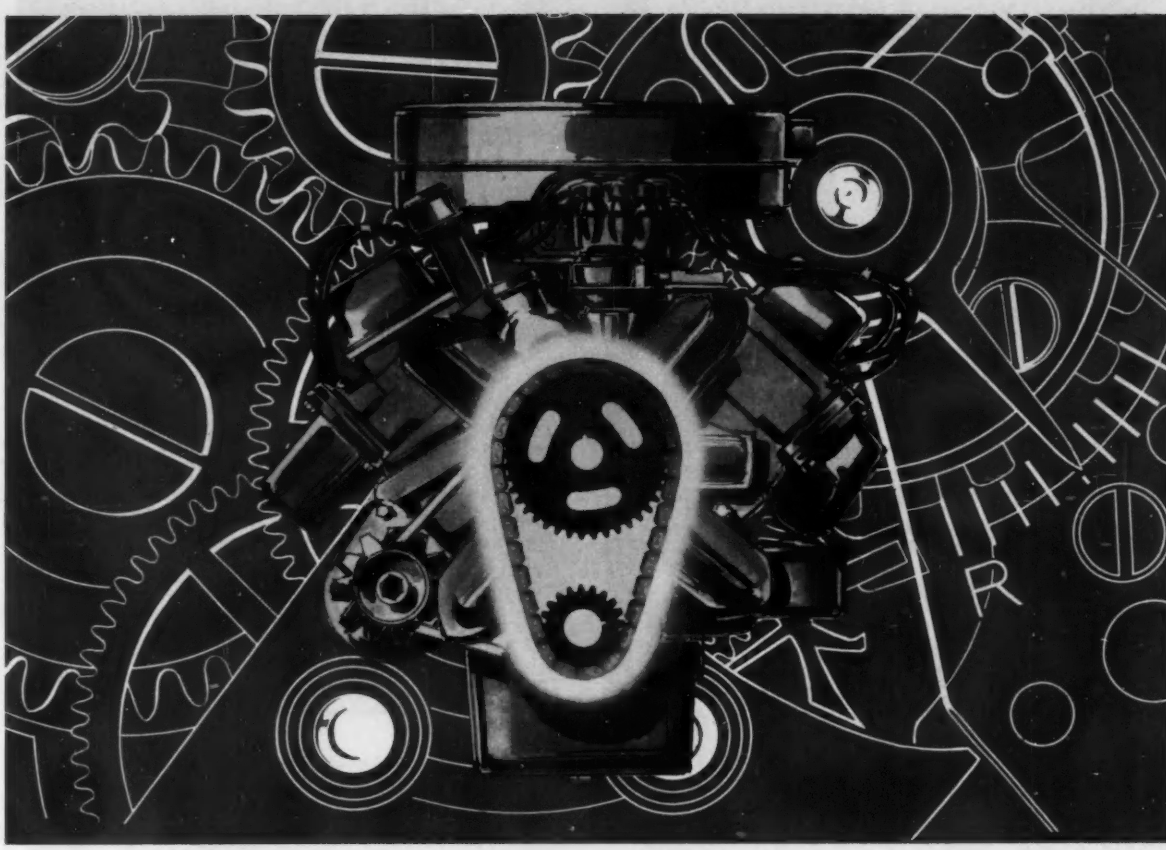
ECONOMY AND STRENGTH are outstanding characteristics of these pressure plates for automotive transmissions. These sintered metal parts are another typical result of the effective liaison between Moraine Products and customer in product design. They also confirm Moraine Products' talent for producing—in quantity and on time—parts that can take the punishment of the most demanding operating conditions.

Parts shown ⅓ actual size

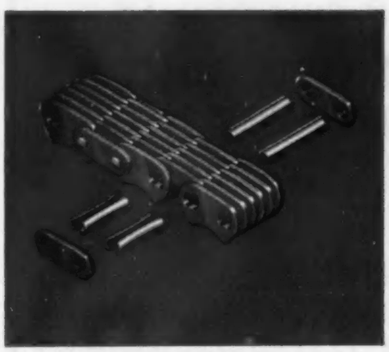
Vital parts for Automotive Progress

Moraine Products

Division of General Motors, Dayton, Ohio



Precise as a watch... and nearly as quiet, Morse Silent Chain times <u>most</u> car engines!



Spring-bushing joint construction of Morse Timing Chain serves as a friction damping device to minimize noise and wear. This new bushing also cuts joint vibration and reduces the tendency to "whip"; provides for take-up of slack. Ask for Catalog C60-51.

Specially designed for passenger cars by Morse ...only company that makes <u>ALL</u> <u>4</u> basic drives

Designed for precision timing of today's high-horsepower engines . . . engineered to passenger-car standards of quietness: this is Morse Silent Chain—original equipment on over 80,000,000 engines.

Actually, Morse Silent Chain is built like a fine watch. And exacting quality controls maintain these rigid standards; insure motorists of trouble-free timing for *extra* thousands of miles. Morse has been building this dependability into timing chain for over 55 years.

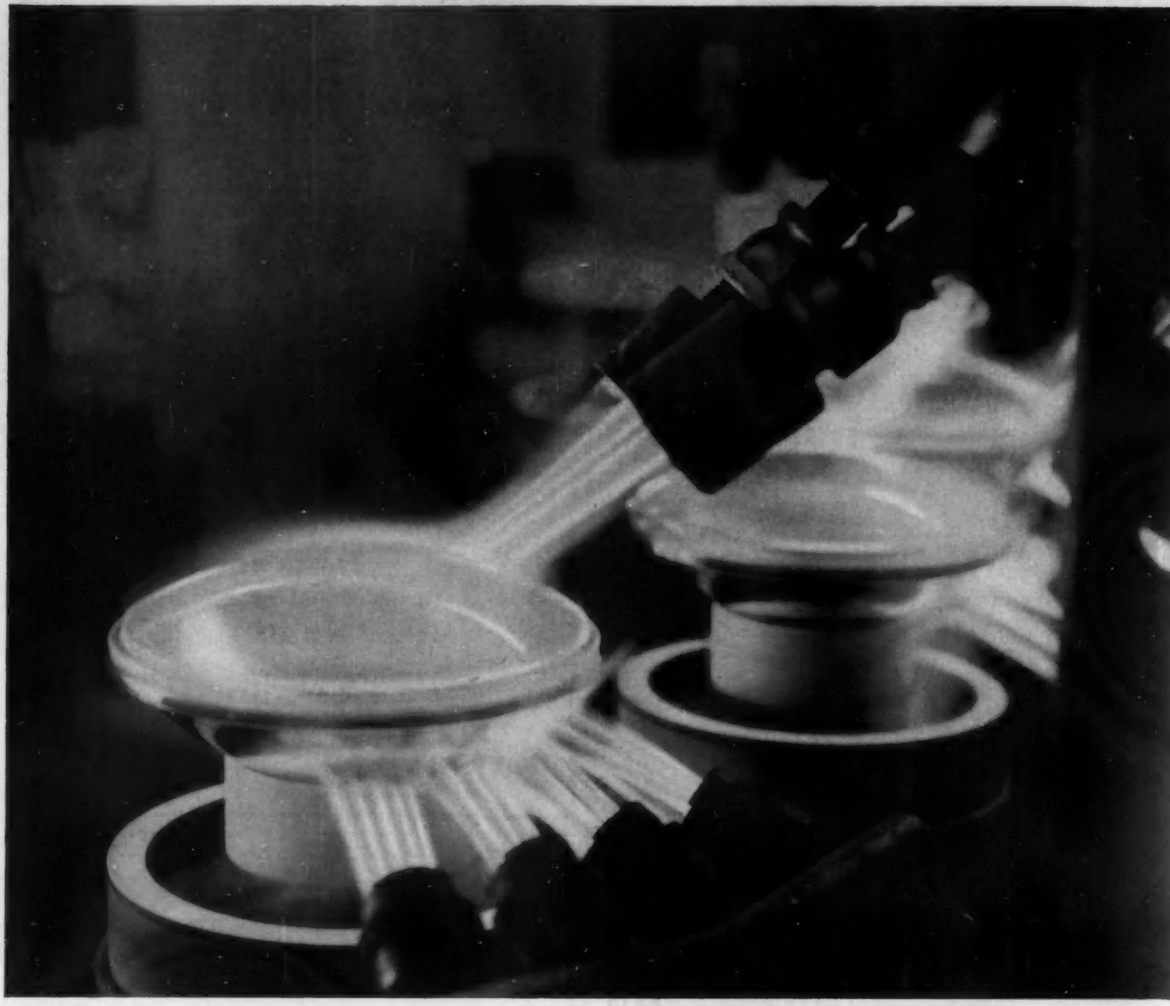
So for original equipment or replacement timing chains, check first with Morse. Want more information or practical engineering help? Call, write or wire today: Morse Chain Company, Detroit, Michigan; Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd.; Simcoe, Ontario.

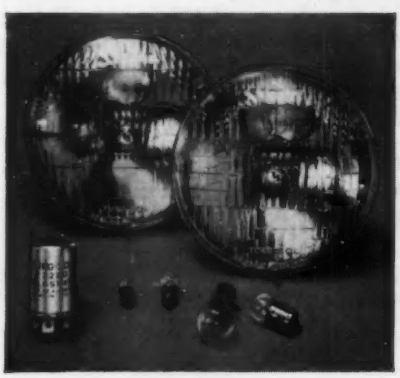
MORSE MORSE B-W BORG-WARNER*

A BORG-WARNER INDUSTRY

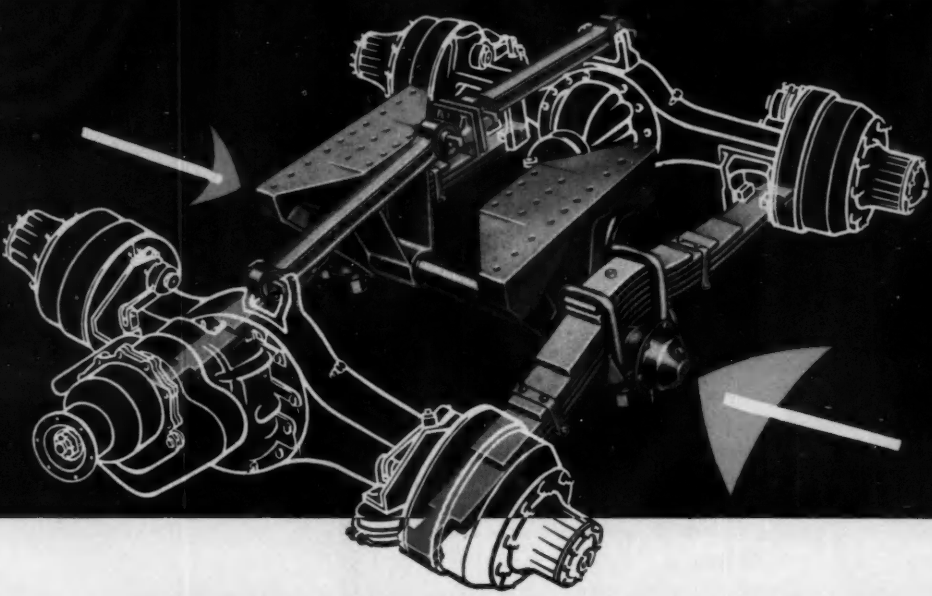
*Trademark

ONLY MORSE OFFERS ALL 4: Roller Chain, Silent Chain, Hy-Vo® Drives and "Timing"® Belts





the NEWEST LIGHTWEIGHT TANDEM SUSPENSION!



MORE PAYLOAD FROM ROCKWELL-STANDARD

Now—Rockwell-Standard adds the latest in lightweight suspension systems to the already famous "Cradle-Ride" Design. Get all these big advantages with the newest, most advanced suspension unit:

Up to 310 pounds lighter! The new all steel Rockwell-Standard Suspension provides weight savings of up to 230 pounds over competitive tandem suspension units . . . *saves up to 310 pounds with aluminum frame support brackets and torque rods.*

Quick, easy maintenance! Removable bolted-on torque rods plus sliding block spring attachment permit easy removal of either axle . . . completely eliminates need for lubrication. Nylon spring seat bushings require minimum maintenance, assure trouble-free operation.

Smooth "Cradle Ride" Design. The famous Rockwell-Standard design that has carried and cushioned tandem loads for years. *The load is more stable . . . driving is easier and safer.*

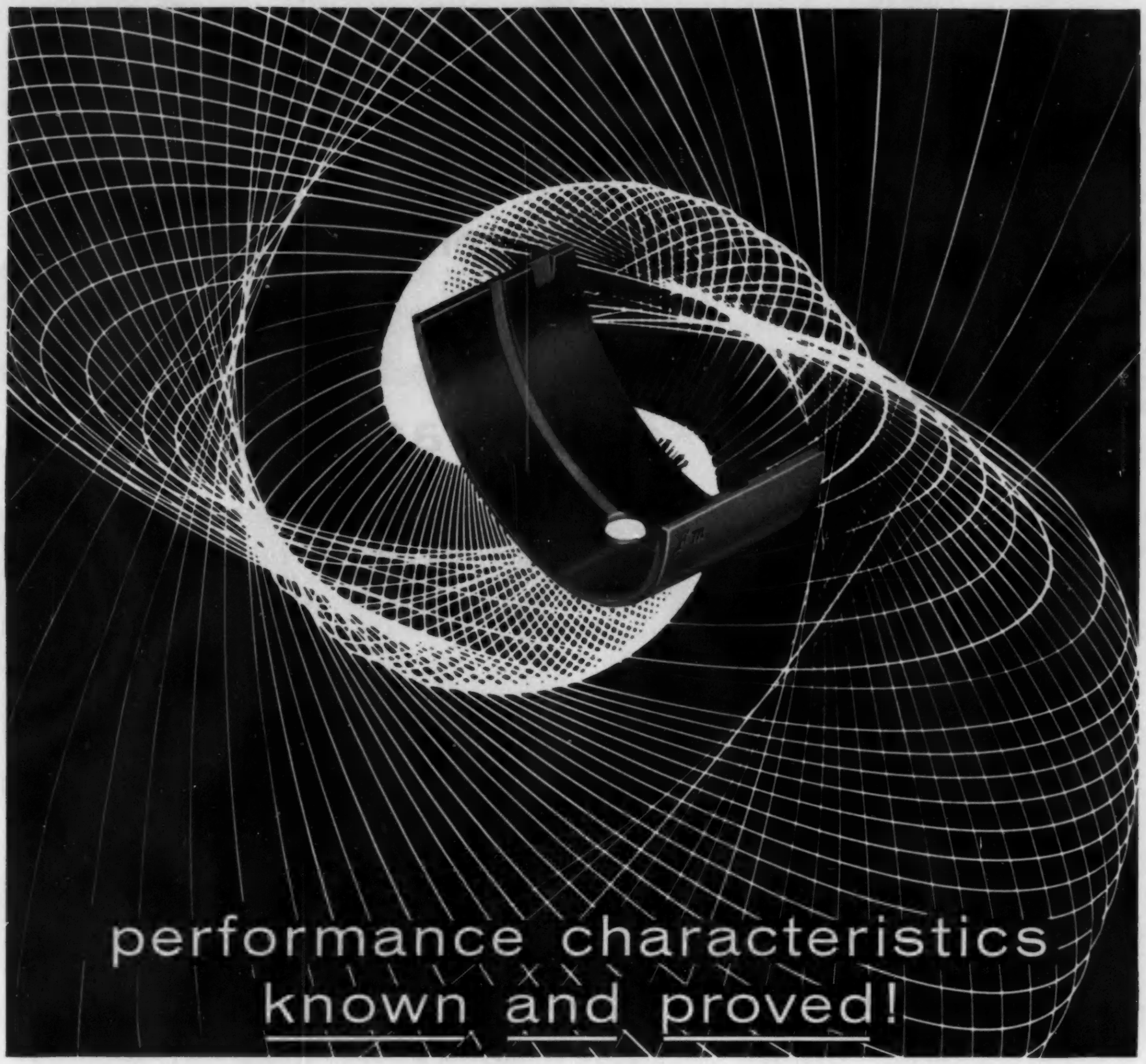
NEW Lightweight Pusher Tandem!

Combines the new lightweight suspension with a Rockwell-Standard drop center axle and single-driving axle to give a pusher tandem unit unmatched in weight savings and balanced construction.

Another Product of . . . **ROCKWELL-STANDARD CORPORATION**

ROCKWELL R STANDARD

Transmission and Axle Division, Detroit 32, Michigan



For 60 years, we have designed, tested and proved countless alloy combinations to meet varying individual engine bearing needs.

Combined with our quality-controlled, high-volume production, this background is constantly used by leading design engineers with sleeve bearing problems.

Babbitts, bronzes, copper-leads, aluminums—we've charted and measured their fields of usefulness . . . performance characteristics . . . individual advantages.

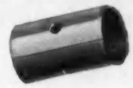
This wealth of experience and know-how is available to you for the asking.

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

Precision Thrust Washers

Spacer Tubes



Bimetal Bushings

Rolled Split Bushings

FEDERAL Mogul SINCE 1899

SAE

Milwaukee Meeting in September features:

2 GSE* Spectaculars

THE COMPLETE RANGE OF GROUND SUPPORT EQUIPMENT to be found at a typical U. S. Air Force base will be shown at two midday SAE programs to be held Monday and Tuesday, September 14 and 15, at the Milwaukee Arena.

THESE UNUSUAL EVENTS will be part of the SAE Farm, Construction, and Industrial Machinery Meeting, September 14–17. Much of the heavy-duty GSE equipment is being built, at least in part, by companies whose engineers will be participating in this Meeting. All of the equipment reflects standardization work undertaken by SAE Committee GSE-1, Military Support Equipment and other SAE technical committees.

THANKS TO THE OFFICE OF THE USAF DEPUTY CHIEF OF STAFF FOR MATERIEL, there will be two noontime displays expected to include missile launchers, propellant tanks, air conditioners for manned aircraft and missiles, mobile fuel filtration units, runway cleaners, and many other items.

AIR FORCE PERSONNEL will be on hand to explain engineering requirements and accomplishments in these lines of equipment.

In addition to the Air Force equipment, the **U. S. ARMY CORPS OF ENGINEERS** will show standard engines and engine accessories and standardized cutting edges.

These modern items will be contrasted with a collection of **OLD VEHICLES ARRANGED BY BROOKS STEVENS.** On parade will be Howard Marmon's early all-aluminum car, a Duesenberg Model A Indianapolis racer, a 1934 Packard phaeton, and other classics.

Ground Support Equipment

+ INDEX TO ADVERTISERS +

For
PERFECT BALANCE
Specify

Genuine

MECHANICS
Roller Bearing
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

The Mechanics Universal Joint has a brake mounting that attaches the brake disc, or drum, to the transmission flange—*independent of the bolts that attach the joints to the flange*. This exclusive Mechanics feature makes it possible to balance the flange and drum—as a unit.

The accurate balance of the brake assembly is not disturbed, when installing the joint, because the bolts that attach the brake drum do not attach the universal joint to the flange—nor carry the universal joint torque. Thus the balance obtained on the balancing machine is maintained after installation of the joint in your product.

Let our engineers show you how this exclusive MECHANICS Roller Bearing UNIVERSAL JOINTS advantage will help improve the operation of your product.

Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

MECHANICS UNIVERSAL JOINT DIVISION
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